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Materials in Design Engineering

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SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

Selecting Sleeve Bearing Materials

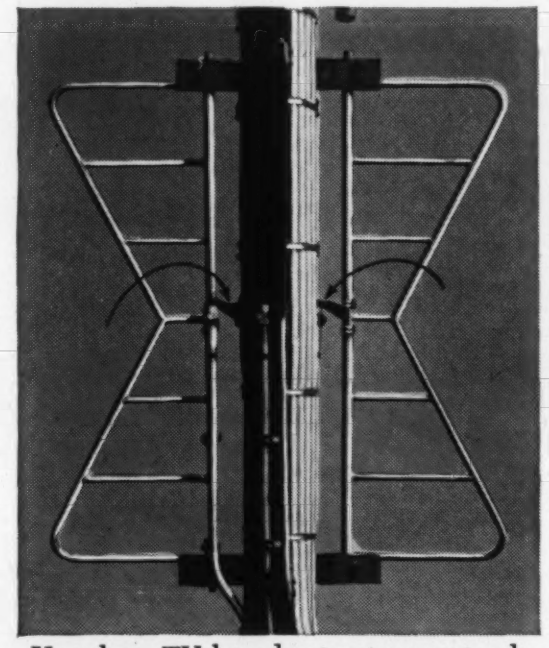
Manual No. 153

Also:
Vinyl-Metal Laminates
Consider Cr-Mo-V Steels
Complete Contents—page 1

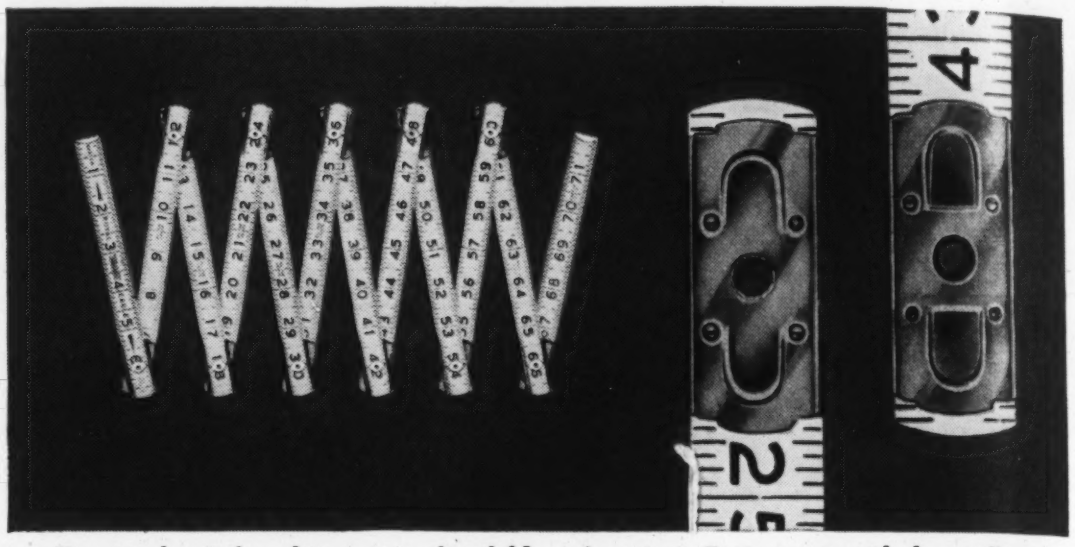
BER, 1958

TRY A FRESH APPROACH

Don't just take your metals for granted—specify the properties you need. The Man from Anaconda may come up with some very interesting answers.

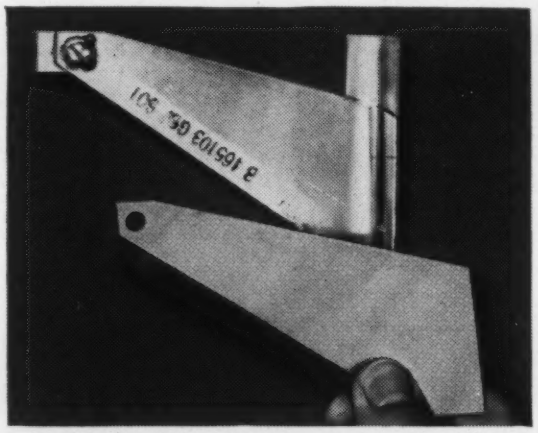


Up where TV broadcast antennas stand, normal wind causes flexing of metals. So jumpers between coaxial cables and radiators must be resilient – beside being conductors, giving some structural support. Ordinary phosphor bronze seemed adequate, but there were fatigue failures.

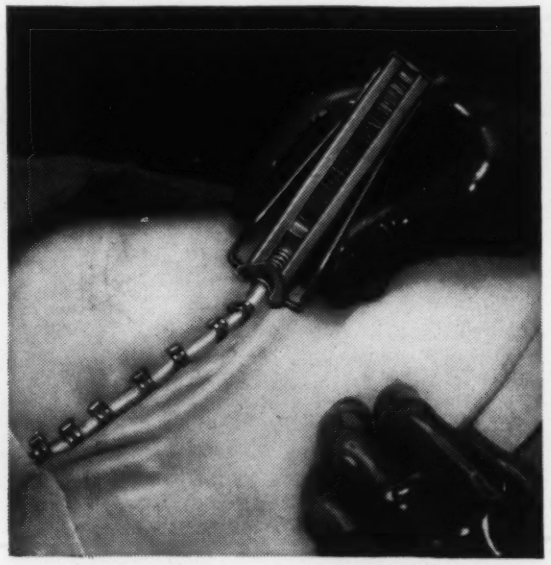


To stimulate sales of its top-quality folding rule, and to meet Navy specifications, Eagle Rule Mfg. Corporation sought a metal for rule joints that would resist wear and corrosion, and provide the proper spring tension. Phosphor bronze, which had these qualities in excess of needs, cost too much.

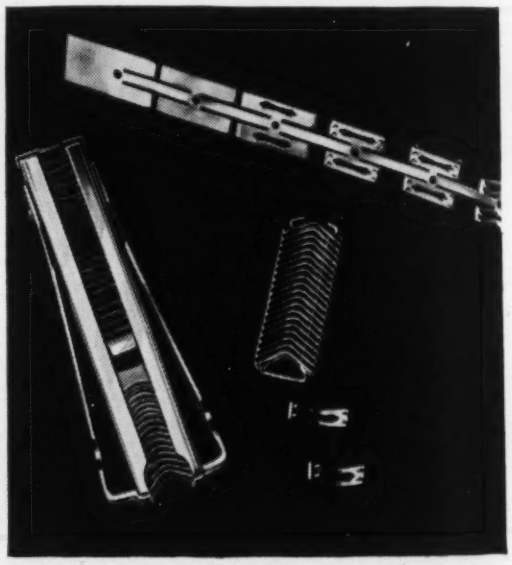
American Brass suggested three alloys. Eagle Rule chose Ambronze-420 (88 Cu, 11 Zn, 1 Sn) because rule joints of this alloy met all requirements, withstood 400,000 cycles in wear test (Navy required 7000). It cost only pennies per pound more than yellow brass, much less than phosphor bronze.



RCA listed desirable properties of phosphor bronze – added *extra*-high endurance, *extra*-long fatigue life. American Brass suggested Duraflex®, Anaconda superfine-grain phosphor bronze. RCA tried it, found it the answer—at no extra cost—specified Duraflex to the manufacturer, Dielectric Products Engineering Co., Inc., Raymond, Maine.



Technical Oil Tool Corp. asked Anaconda to help select the metal for a new magazine-type clip used to close surgical incisions. The metal had to provide the right tension to hold edges together, yet open easily—form readily, hold sharp die-cut edges, be proved in surgical use.



American Brass technical specialists suggested Nickel Silver, 18%-719 as best suited to meet all requirements. Autoclip, shown in use above, is the result. Incisions are held together with least damage to tissues. Surgeons can work faster in applying and removing clips.

STARTING with 93 standard alloys, The American Brass Company can make minor variations in composition, fabrication, and annealing to provide an almost unlimited number of combinations of useful properties. When new or unusual problems arise, ask for the help of the Technical Dept. in selecting the right metal. For such help or a copy of Publication B-32, "Anaconda Copper & Copper Alloys," write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario, Canada. 5850

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Materials
in Design Engineering. *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

OCTOBER 1958
VOL. 48, NO. 4

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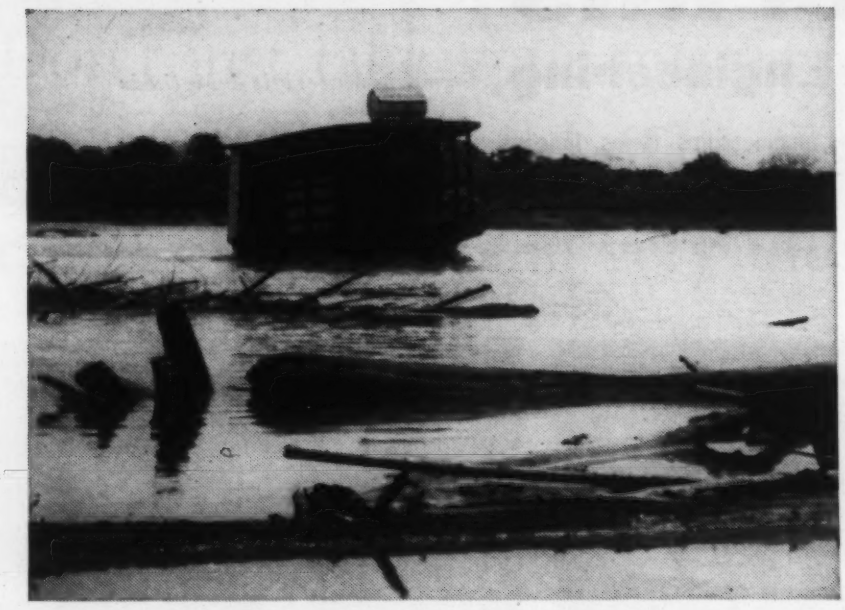
Jungle missionary straightens out shaft problem



Hazardous passage. Drifting debris, submerged rocks and ever-shifting shoals pose constant threats to this missionary. He is Brother Dismas of the Maryknoll Fathers, whose frequent missions take him up and down uncharted, unpredictable waters deep in the jungles of Bolivia.

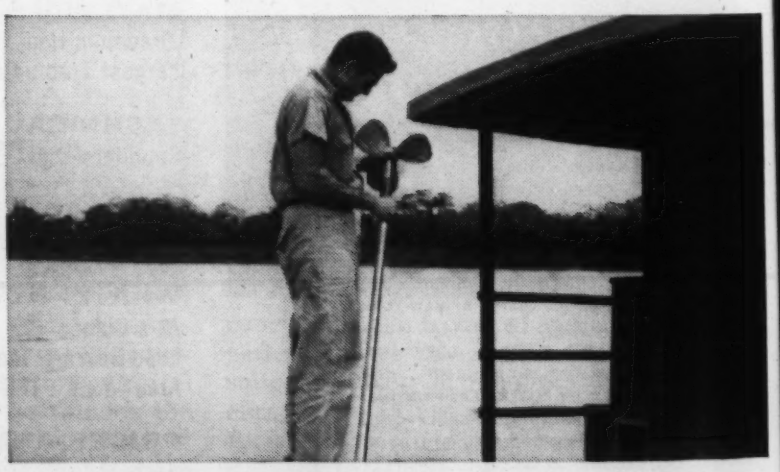
There's no telling what he may run into here. One of the menaces is the dead *Tajibu* or "vegetable iron" tree.

A giant hardwood, the *Tajibu* dies and topples into the river. The wood is so heavy the whole tree sinks. And so *hard* it's been used in place of bearing metal. Imagine what happens when a *Tajibu,* cartwheeling along in the swiftly running current, tangles with the boat's slender drive shaft . . ! It's virtually impossible to detect one fast enough to avoid being rammed.

Man-eating Piranhas and alligators lurk in these jungle rivers, but Brother Dismas dives in and removes bronze propeller shaft, bent in collision with an unseen *Tajibu*. With nearest help several days' journey away, he has no alternative but to attempt an on-the-spot repair.

Riverside "shop"—The bent bronze shaft is first heated over an open fire, then placed on a log and hammered straight. This primitive repair job has to get him back to his base. "After a few experiences like this, I got a bright idea," says Brother Dismas. "I decided to try one of your Monel shafts.

"Monel shaft arrives . . . and was I glad to see it. I've found that bronze shafts bend too easily in these rivers and steel shafts corrode and chew up bearings. We picked up our new Monel shaft in an ox cart at the airport and were underway with it in record time. Now we have . . .



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What's new IN MATERIALS

...AT A GLANCE

HEAT TREATED TITANIUM SHEET said to withstand stresses inflicted on manned aircraft flying at 2100 mph is now commercially available. The sheet, Ti-4Al-3Mo-1V, is heat treated to 1600 F by a quick, powerful jolt of electricity, then suddenly quenched by hundreds of gallons of water. The heat treated sheet has a tensile strength of 190,000 psi.

A TAC-POLYESTER RESIN THAT WITHSTANDS 500 F continuously and 1000 F intermittently is now commercially available. The triallyl cyanurate-modified polyester is reported to have excellent dielectric properties combined with a radar transparency rating about ten times that of conventional polyesters. The material is said to be ideal for radomes and nose cone housings for radar equipment on manned and unmanned aircraft. (More details next month.)

COMPARATIVE RUST RATES have been exactly established for all U.S. cities over 10,000 population. It takes three years, the fastest rate in the country, for a 28-gage, low carbon, cold rolled sheet steel to severely rust in Buffalo and Rochester, N.Y., Erie, Pa., and Miami, Fla. Slowest rust rate (more than 15 years) is in Tucson, Ariz., and Roswell and Santa Fe, N.M.

STATIC-DISPERSING POLYSTYRENE RESINS, with surface resistivity values low enough to permit static charges to equalize on the surface of molded parts, are now available. Dispersion of static charges breaks up static patterns introduced during molding and eliminates dust patterns commonly encountered in parts exposed to atmospheric dust and dirt. Potential uses for the resins include clock housings, displays, furniture drawers, and grilles for fans and air conditioners.

AN IMPROVED METHOD FOR CONTINUOUSLY CASTING METAL STRIPS has been developed in England. A nozzle impinges a high speed jet of molten metal onto the surface of a rapidly rotating chill block; the metal solidifies on the block and is then thrown from it by centrifugal force.

BETTER ELECTRICAL INSULATIONS FOR WET AREAS can be obtained by using newly developed glass-base melamine laminates. Tests show the laminates have a dielectric strength more than twice that of

What's new IN MATERIALS

conventional laminates after 336 hr immersion in water at 120 F. The glass-base laminates, not yet commercially available, are also said to have good craze resistance. (More details next month.)

A NEW ALUMINUM EXTRUSION ALLOY is said to produce parts having better mechanical properties and surface finish than parts made from conventional extrusion alloys. The alloy, said to belong to the magnesium silicide group of aluminum alloys, can be used to extrude boat masts, tubular furniture, appliance trim, ski poles, window frames, railings and brackets.

QUARTZ TUBING COMPARABLE IN SIZE TO A HUMAN HAIR is now commercially available. According to the producer, the tubing is so small that it takes a 50-ft length to hold a drop of water. The tubing has tensile strength greater than steel, has good heat and chemical resistance, is flexible, and is a nonconductor of electricity. It is expected to find use in a diffusion cell for recovering helium.

LEAKPROOF HYDRAULIC FITTINGS can be obtained by using a new metallic seal that deforms and becomes an integral part of the fitting with the application of torque. The seal, made of aluminum, stainless steel or Inconel X, is effective from -360 to 1200 F and from 0 to 10,000 psi, depending on the material used.

WIRES AND CABLES CAN BE JACKETED QUICKLY by using a newly developed zippered copper tubing. Jacketing is done by enclosing wires and cables in the tubing, then zippering it shut on a plastics or metal zipper track. The tubing is made of copper foil laminated to vinyl-saturated fiberglass.

A NEW CLASS OF CERAMIC MATERIALS has been discovered that can convert the heat of a burning fuel directly into electricity. They are described as "mixed valence compounds of the transition metals." The new thermoelectric materials, still in the development stage, can operate at temperatures of 2000 to 3000 F. They are reported to have thermoelectric efficiencies at these temperatures comparable to those of the most promising intermetallic compound, lead telluride, at temperatures under 1000 F.

A HIGH-DAMPING MAGNESIUM ALLOY for missile parts has been developed. Said to have excellent resistance to sound wave vibrations, the alloy, containing 0.6-0.7% zirconium, is expected to find use in the Nike-Hercules missiles where weight limitations prohibit the extensive use of shock mounts.

Turn to page 139 for more "What's New in Materials"

MATERIALS BRIEFS

Clear Color Gets Brush-Off

Hairbrushes, whisk brooms and industrial brushes will probably be more colorful with the introduction of colored nylon brush filaments. The colors—beige, aquamarine, pink, blue, yellow and red —were chosen on the basis of general public acceptance or rejection of colors.

Epoxy Stops Cars

A specially formulated epoxy resin containing grit is being used to make highways and bridges skidproof. The material is said to stop cars in one-half to three-quarters of the distance required on plain concrete.

Injection Molded Shoes

Plastics shoes that are said to be practically indestructible, never need a shine, and never need repairs are being turned out at the rate of two pairs a minute in a modified injection molding machine. The shoes are made of a specially formulated PVC resin.

Paper May Suit You

Knit paper T-shirts, suits, sport coats and dresses may soon be draping the well-dressed man and woman. The paper garments can be sewn, patched, dry-cleaned and reused.

A Golden View

Electrically heated window glass is now available for automobile as well as aircraft windshields. Such windshields, heated by current carried through a transparent film of gold deposited between sheets of glass, are said to stay free from ice and mist.

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QUALITY CONTROL

Instruments & Tests

A rigid quality control system is set up to insure that all material meets our or our customer's specifications. Samples from every batch are checked during processing and when completed. Incoming ingredients are also checked for quality.

Some of the instruments our well equipped laboratory uses are:

Abbe refractometer
Sartorius balance
pH meter
Melting point apparatus
Gravitometer
Brookfield viscometer
Microscope
Fremet
Weather-ometer
Fadeometer
Oxygen bomb
Ozone
Humidity cabinet
Mooney Plastometer
Scott Tensile Tester
Ozone cabinet

☆

Materials-Control Instruments and Tests

The Abbe refractometer is used to check the purity of plasticizing oils and solvents. The microscope with its screw micrometer eyepiece measures thickness of skin on automotive and other type strip. Viscosimeters check viscosity of oils, solvents and cements. Melting point apparatus and ash serves check the purity of solids and their particle size. An analytical laboratory checks for traces of impurities which would affect the final product.

☆

Grades of Sponge Rubber

The American Society for Testing Materials is a national technical society composed of producers, consumers and members of interested groups such as research organizations, colleges, etc. In the past fifty years it has established a large number of standards and standard test methods on almost every type of material. We provide materials which meet the ASTM specifications recognized by many of our customers, including automotive, airplane, and other large manufacturers. ASTM designation D 1056-54T* is the specification number covering both cellular rubber testing methods and grades. This number in itself means nothing; the properties of the rubber are given by the letters and numbers in the tables of the specification. The prefix letters designate the type of rubber, i.e., R stands for rubber, either natural or synthetic, where oil resistance is not required. (Formerly this was RN for natural rubber and RS for synthetic). SC stands for rubber with good oil resistance, usually Neoprene, and SB for excellent oil resistance, usually a Nitrile rubber. The prefix letters are followed by numbers which denote the type (open or closed cell, or foam) and the firmness and by suffix letters (see page 25) when special qualities are required.

A standard test sample disc, 1 square inch in area and ½" in thickness, is used for testing. When possible this is cut from the part itself, but if the shape of the part precludes this, a standard ½" test slab is made from the same compound and tested.

*Formerly Specification D-70R and test methods D 552.

☆

Compression

In compression the degree of firmness regulates to a great extent the type of sponge rubber that can be used for a given application so it is only natural that sponge rubber should be classified by its firmness. This has been done by the ASTM which has set up six grades based on the force necessary to compress a sample, one square inch in area, to 75 per cent of its original height. We manufacture sponge rubber to meet all of these grades. In addition, we have special compounds to meet the suffix letter requirements, such as low temperature, high temperature, non-staining, adhesion, weathering, etc. These grades (for natural rubber) are given below, with our sheet stocks which correspond to them. A more complete list is found on page 24.

ASTM GRADE NO.	COMPRESSION TO 75% LBS. PER SQ. IN.	OUR STOCK NO.
R 10	½ to 2	1223
R 11	2 - 5	1325
R 12	5 - 9	1525
R 13	9 - 13	1725
R 14	13 - 17	1825
R 15	17 - 24	1925

☆

Graphs showing the complete compression — deflection curves of these stocks are given below.

☆

A sample disc, one square inch in area, is cut from every roll of sheet machine stock we manufacture. This is tested and graded by ASTM standards. Quality control graphs maintained on these tests show the compression, compression-set, aged compression change, density and thickness. These graphs are constantly watched by the Production Department to see that quality is maintained.

☆

For cord and molded goods, standard practice in the industry is to prepare and test a slab of the same compound. This is not always conclusive and therefore not entirely satisfactory. We have developed special tests that can be made on the finished product. Examples of these special test requirements are found on the many molded items we make. Automobile parts, such as weatherstripping, trunk seals and cowl gaskets are tested by applying sufficient force to compress a 12" length ½". Horn rings, bicycle seats, sponge balls and such are given special tests on the completed part, the type of test depending on the specific property most important for the application.

☆

Compression-Set

Rubber compressed for an extended period of time does not completely regain its original height. This loss in height is called "compression-set." This figure must be kept low or the rubber loses its ability to form a close seal.

We continually have requests from customers for information as to what set the rubber will take in their applications. The conditions of use vary as widely as the innumerable uses for sponge rubber. To get basic information we have run compression-set tests under different conditions of time and temperature on standard ½" samples. Thinner stocks may have poorer sets than those in some cases due to the thickness of skin in relation to the total thickness. However, the test samples were taken from regular production and are representative of our product.

The standard compression-set test for sponge rubber is to compress the sample to 50 per cent between two steel plates. At the end of the test period, usually 22 hours at 158° F., but also run at room and other temperatures, and for varying periods of time, the sample is removed, allowed to rest for 30 minutes, and measured. The per cent loss in height is the compression-set figure.

In the ASTM method, the compression-set is figured as the per cent of the deflected height lost. This gives a figure just double that of the original height lost and has led to considerable confusion. Therefore, if the compression-set is given as an ASTM figure, just divide by two to get the actual % height loss.

Room Temperature

Our stocks show a remarkably low set at room temperature. After being compressed 50% for 40 hours, the average set of hundreds of samples is around 2-3 per cent. Graph II shows compression-set curves of two of our stocks over an eight year period. At the end of eight years, sets averaged between 30 and 35 per cent. This should be a convincing argument that these stocks could be used as gaskets or in compression for an extended period without losing their sealing properties.

Elevated Temperatures

The standard ASTM compression-set test is for 22 hours at 158° F. By this test our production stocks, when made into standard ½" ASTM test slabs, will be within the ASTM limits.

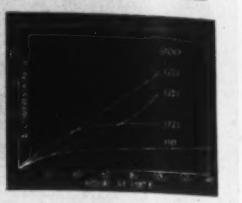
☆

As noted before, thin stocks, due to their fast cure and comparative skin thickness, tend to have higher sets.

At longer times or higher temperatures, compression-set increases. Although sponge rubber should not be used in compression at elevated temperatures where low set is desired (as the compressed gasket), it is possible to go beyond the test times and temperatures and still have some sealing properties left.

Graph III shows the change in compression-set over a period of 100 hours at 158° F. Our 1101 stock, especially compounded for high temperatures, was kept in compression for 7 days. At the end of this time, the set was under 10 per cent.

At temperatures of 200° F., for 22 hours, all stocks but 1101 have sets of over 40 per cent and at 46 hours regain only a few per cent of their compressed height. However, 1101 has a set of only 20 per cent after 46 hours at 200° F. Therefore, if a material is required which must have a low compression-set at higher than normal temperatures, our 1101 will give excellent results.



Influence of Heat and Aging

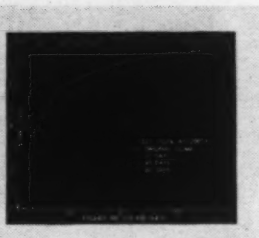
One of the most frequent questions we receive concerns the temperature range of sponge rubber. Will it stand two hours at 275° F.; a month at 175° F.; steam, heat and cooling cycles, etc.? These questions are difficult to answer because conditions in actual use are always different. To obtain further information on this subject we have run complete compression-deflection curves on our ½" sheet stock at different times and temperatures.

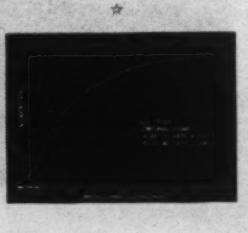
High Temperature Aging

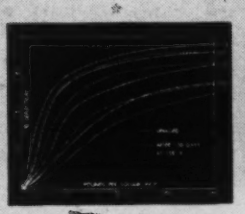
The standard seven days at 158° F. test has little effect on our sponge rubber. Therefore, we have run this test for 120 days — a solid four months in the oven. As a week at 158° F. is considered the equivalent of six months to a year of natural aging at room temperature (not exposed to sunlight) it can be seen that sponge rubber will be serviceable for years under normal room conditions.

Graph IV shows the change in compression after this test. The curves are roughly parallel — with a change in firmness averaging but a few per cent, usually between 5 and 10 per cent.

At higher temperatures sponge rubber hardens more rapidly. For example, 1223 stock at 200° F., as shown in Graph V, hardens but little after twenty days; is firmer, but still serviceable after forty days, and, at sixty days, is practically solid. 1325 stock acts the same way.







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Stocks 1525, 1725 and 1825 contain compounding ingredients which add to their firmness and which are necessary to make them meet their ASTM classifications. These materials harden at elevated temperatures and, therefore, these stocks will not stand long periods at 200° F. Graph VI shows 1525 after twenty and forty days; 1725 and 1825 are similar.

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☆

Tensile and Elongation

As sponge rubber is used in compression, tensile strength is not the important property that it is with mechanical rubber. However, some compounds still require a minimum value in their specifications. The tensiles of our crude rubber stocks are extremely good. It is hard to give definite figures because thin stocks, due to higher density, have higher tensiles than thick, lower density strocks. However, 1332 runs from 75-100 psi tensile and 500-600 per cent elongation up to ½". Tensiles and elongations then decrease to 30-50 psi and 350-450 for 1" stock. 1523 runs about the same in tensile with lower elongation and 1725 has a higher tensile average with elongation running to 300-400 per cent.

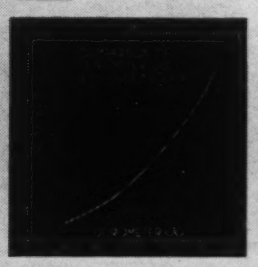
These values are taken at the breaking point, i.e., a 75 psi tensile and 500 per cent elongation means that it would take 75 pounds to break a sample one square inch in cross-section and that the sample would stretch 500 per cent (a one inch length would stretch to six inches) before it breaks. The good tensiles and higher elongations of our sheet stocks mean that the sponge can be stretched considerably without breaking.

☆

Durometer

For many years the Shore Durometer "OO" has been used to check the softness of sponge rubber. Due to its convenience and speed, it is still used, although generally replaced by more accurate methods of testing compression. Different people will get different results on the same material, using the Durometer, and thin stocks will have a higher reading than thick (as in tensile). Bearing these facts in mind, we can say that 1323 stock falls in Durometer "OO" range of 25-45; 1523 averages 35-60, and 1723 falls between 45-70.

Many people use Durometer "A", made for mechanical rubber, and often ask how our values compare. Below is a graph comparing the two Durometers.



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This conversion graph is not to be considered accurate on all stocks as any surface hardness tester evaluates modulus at low elongation if the reading is taken immediately and modulus at low elongation plus plastic flow if an interval elapses before reading. Thus, not only the pressure used by the operator, but also the time he takes in making the reading, influences the result.

Insulation Value — Heat

The insulation value of a material is the property it possesses of slowing down the transfer of heat. This property can be measured and expressed in a number called the K factor. K factor is defined, in English units, as the amount of heat in B. T. U. (British Thermal Unit) which will flow in one hour through a square foot area 1" in thickness with a temperature gradient of 1° F. A B. T. U. is the amount of heat necessary to raise one pound of water one degree Fahrenheit.

Representative samples of sponge rubber have been tested and found to have a K factor of 0.66. This is higher than most insulating materials and much higher than our Cell-Tite, the non-interconnecting cell structure of which is responsible for a K factor of 0.20 to 0.25.

☆

Insulation Value — Sound

Sound insulation is a complex problem. There is no one value, like the K factor for heat insulation, which tells the whole story. The sound absorption coefficient and sound transmission coefficient are both used in acoustical measurements and of these the former is probably more useful as it can be compared with the published values of many other materials. We have had this sound absorption coefficient measured for our ½" 1223 by the Tube method. In this method a "wall" of sponge rubber is placed at one end of a tube and a sound of definite frequency introduced at the other. The sound waves travel through the tube and hit the rubber where some are absorbed and some are reflected. The reflected waves unite with the original waves and, at certain points where they meet in phase, reinforce them and produce a sound of maximum intensity. Where they meet out-of-phase a minimum sound is heard. These points are determined electronically and by use of a fairly simple formula the sound absorption coefficient is figured.

For our ½" 1223 these values are:

Frequency cycles per second	Sound absorption coefficient
256	0.800
512	0.310
1024	0.845
2048	0.900
4096	0.585

For normal auditorium acoustical problems, the coefficient of sound absorption at 512 cycles is commonly accepted. Sponge rubber is exceptionally good at absorbing the higher frequencies.

The average of the sound absorption coefficients for 256, 512, 1024, and 2048 cycles per second is often used as the noise reduction coefficient. In the above case it would be 0.715.

☆

Staining and Tarnishing

There are three general types of staining: Discoloration of the stock itself, i.e., white rubber turning yellow; light blue darkening, etc.; contact stain, and migration stain. The first class does not prove too troublesome as we buy the best colors and compound for maximum color stability. Contact stain as defined by ASTM, occurs when rubber is in close contact with a lacquered or enamelled plate under heat. Migration stain occurs when rubber is in contact with the plate under ultra-violet and heat. This is the most important test to us due to the many automotive parts we make.

A standard test for automotive staining originated by Fisher and adopted by ASTM, makes use of a lacquered panel exposed to ultra-violet rays of a sun lamp for a definite time and distance. By this test, some of our crude sheet stocks stain.

When in contact with wood or paper under room conditions, no stain occurs. However, different types of paint and lacquer will react differently and, in case of doubt, the customer should furnish a sample of the material he uses for us to use in making special tests.

Vinyl plastics, due to the stabilizer used, will generally be stained through action of the sulfur in the rubber. Sometimes a fabric backing on the vinyl prevents this.

Metals will usually be tarnished by continued contact with sponge, especially at elevated temperatures. This also is caused by the sulfur in the compound. For special cases we have a sulfur-free compound which will eliminate this trouble. Our 1423D, Sulfur Free Stock, was tested by inserting shiny dimes in slits in the rubber, and kept at 158° F. for 7 days. At the end of this period, there was no tarnishing and the dimes were bright. When tested in standard sulfur bearing sponge, the dimes were badly tarnished.

In addition to this compound, we have 1603, a low sulfur compound, especially made for being covered or in contact with vinyls. Sulfur bearing sponge often stains or discolors vinyl sheeting, especially the light colors. 1603 either eliminates or keeps this discoloration to a minimum.

Fungus Resistance

Natural rubber and the common man-made rubbers which we use are practically free from fungal attack. When growth occurs, it is usually due to foreign matter on the surface of the rubber. It is not necessary to add fungicidal materials to sponge under most conditions.

Vermin Resistance

Like fungus resistance, rubber is to a great extent vermin proof. This is of great importance to our many rug underlay customers. We have had extensive tests made by one of the country's largest laboratories whose conclusions are that it is possible for carpet beetles to reproduce on practically any surface, but on sponge rubber their growth was considerably retarded and larvae were much smaller than normal. Under these conditions, they would normally migrate in search of food.

☆

Resistance to Oils and Chemicals

We have many inquiries as to the effect of various chemicals on sponge rubber. The swelling or shrinkage of sponge rubber is an important property to be considered in many applications. If the sponge swells unduly, it becomes soft and mushy, without strength. The ASTM considers as "medium swell" one that increases less than 60 per cent in volume after 22 hours immersion at 158° F. and a "low swell" stock increases less than 10 per cent.

1101 Stock — for High Temperature Resistance

(Available on special order, minimum requirement necessary.)

Our high temperature stock No. 1101 is an extremely versatile material. Originally designed to give good heat resistance, it also has excellent compression-set and low temperature characteristics. By the standard ASTM method the compression-set ranges from a little over five per cent for 22 hours at 158° F. to less than ten per cent for 166 hours. At 200° F. the set is under 12 per cent for 22 hours and 20 per cent for 46 hours. Even under the extremely severe conditions of 72 hours at 225° F. the set averaged between 35 and 40 per cent.

At high temperatures 1101 stock can be used where standard rubber compounds fail. 200° F. — 225° F. have little effect on its softness even after 30 days. At 250° F., twelve days make little change, but at fifteen days the stock begins to harden, and at eighteen days it is very firm.

At 275° F. the limit of continuous use is between three and four days. At five to six days the stock is hard.

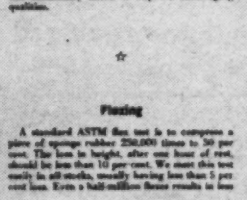
For low temperature resistance 1101 stock is surpassed only by 1343 in crude rubber compounds. At −40° there is little hardening and at −67° F. (−55°C.) the change is not great, as is shown by Graph XVII.

Silicone — for extremes of temperature

For uses where continuous temperatures over 350° F. are unavoidable, or for extremes of both high and low temperatures, Silicone sponge and Silicone Cell-Tite (a closed cell material) have been developed by our laboratory. Silicone rubber combines the stability of the Silicones with the elastic properties of rubber. It has resistance to aging and retention of chemical and physical properties at temperatures far above and below the limits of rubber.

Silicone is several times the price of rubber, but our Silicone Sponges, due to its light weight, is much cheaper than silicone solid rubber.

Silicone Sponges is, to some extent, a custom made product. We can compound this material to meet the customer's requirements, whether it be high tensile, low compression set, extremes of temperatures, etc. Our standard compounds are those which have the best balance of properties, including economy of production, and are considered general purpose stocks. It should be remembered that emphasizing one quality is usually at the expense of another.



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Other Aging Tests

In addition to the aforementioned aging tests, we use oxygen-bomb and air-bomb tests; weatherometer or artificial weathering tests, and natural sun aging tests. The bomb tests are conducted at elevated temperatures at 60 psi air pressure or 300 psi oxygen pressure. Our stocks easily pass ASTM and government specifications for these tests. The weatherometer is a machine that subjects the rubber to a spray (rain), a stream of air (wind), and carbon arc light (sun). In 100 hours the material is given the equivalent of approximately six months in the open. By these means and by outdoor exposure tests on our roof and in Florida, we check our products constantly and continually strive to improve their aging qualities.

☆

Flexing

A standard ASTM flex test is to compress a piece of sponge rubber 250,000 times to 50 per cent. The loss in height, after one hour of rest, should be less than 10 per cent. We meet this test easily in all stocks, usually having less than 5 per cent loss. Even a half-million flexes results in less than 10 per cent height loss. This is of great importance as it is one of the most valuable properties of sponge rubber. It means, for instance, that in vibration dumping, the sponge rubber can be compressed millions of times without structural breakdown.

☆

These pages and 18 more are yours for the asking

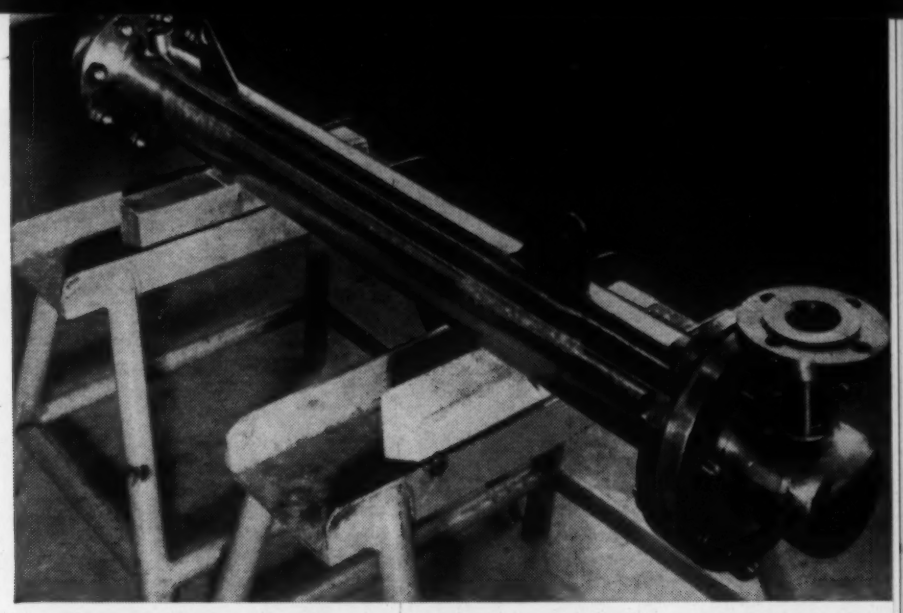
For this informative 26-page reference guide on cellular rubber, its properties and uses, write The B. F. Goodrich Company **421** *Derby Place, Shelton, Connecticut*

B.F.Goodrich *industrial cellular materials*

For more information, turn to Reader Service card, circle No. 530

MATERIALS AT WORK

New and interesting applications of engineering materials

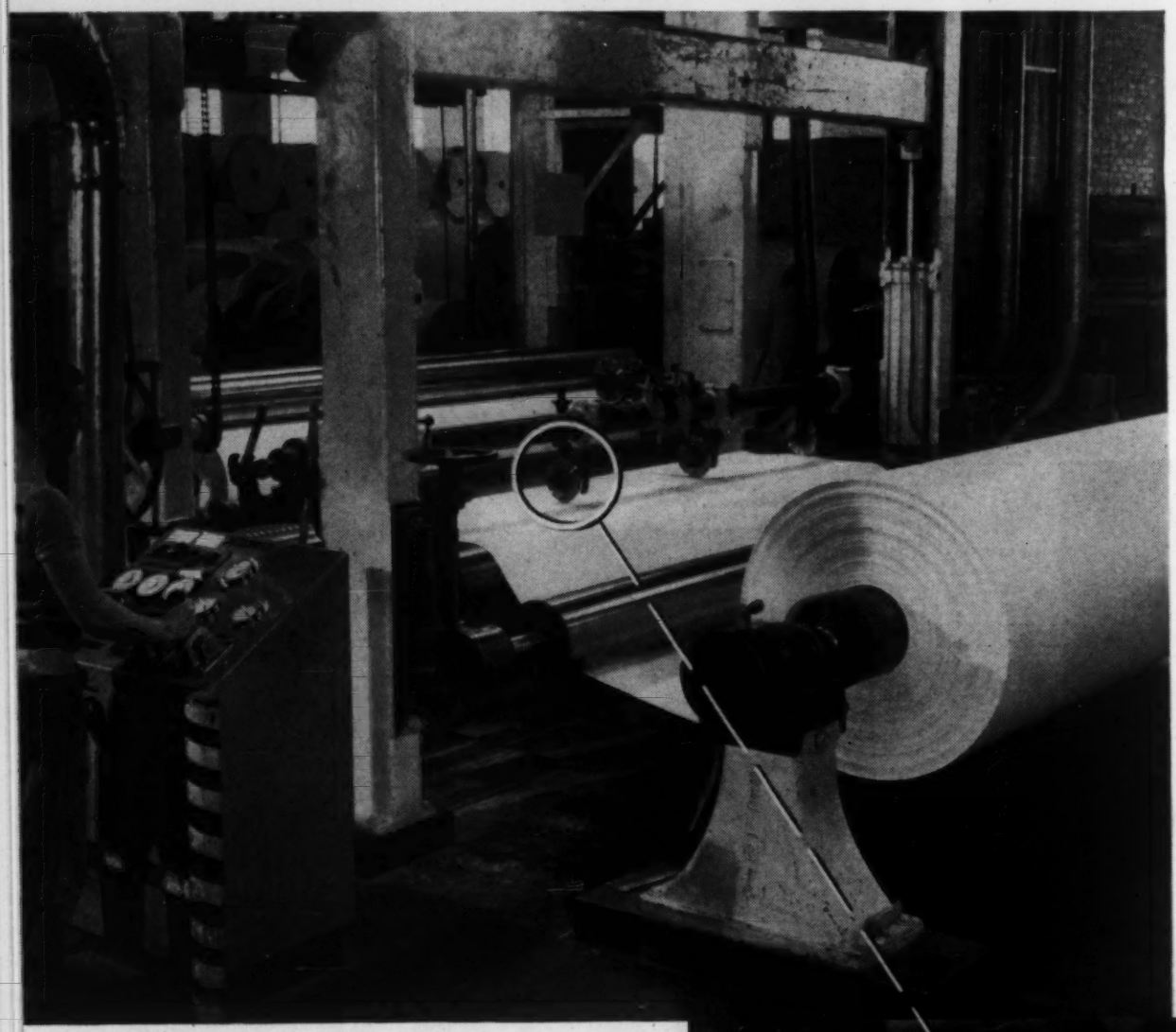


First zirconium heat exchanger

Shown in the top photo is the "world's first zirconium shell and tube heat exchanger." The 11½-sq ft unit has solid zirconium bonnets and tubes and zirconium-lined tube sheets. The 4½-in.-i.d. shell is constructed of polished type 304 stainless steel.

According to Pfaudler Co., zirconium was selected because of its excellent resistance to concentrated acids and alkalis. However, many problems had to be overcome before the unit could be successfully fabricated: zirconium is difficult to cold form, it cannot be welded to other metals, and it has an affinity for atmospheric oxygen and nitrogen during welding.

To fabricate the unit, therefore, the material was heated to 600-900 F prior to forming. Bonnet heads were pressed on a hydraulic, and bonnet shells were hot roll formed, machined and welded to the bonnet heads. Welding was accomplished with a tungsten arc in an inert argon atmosphere within a specially constructed chamber (see bottom photo).



Paper is slit *as it rolls through machine by . . .*

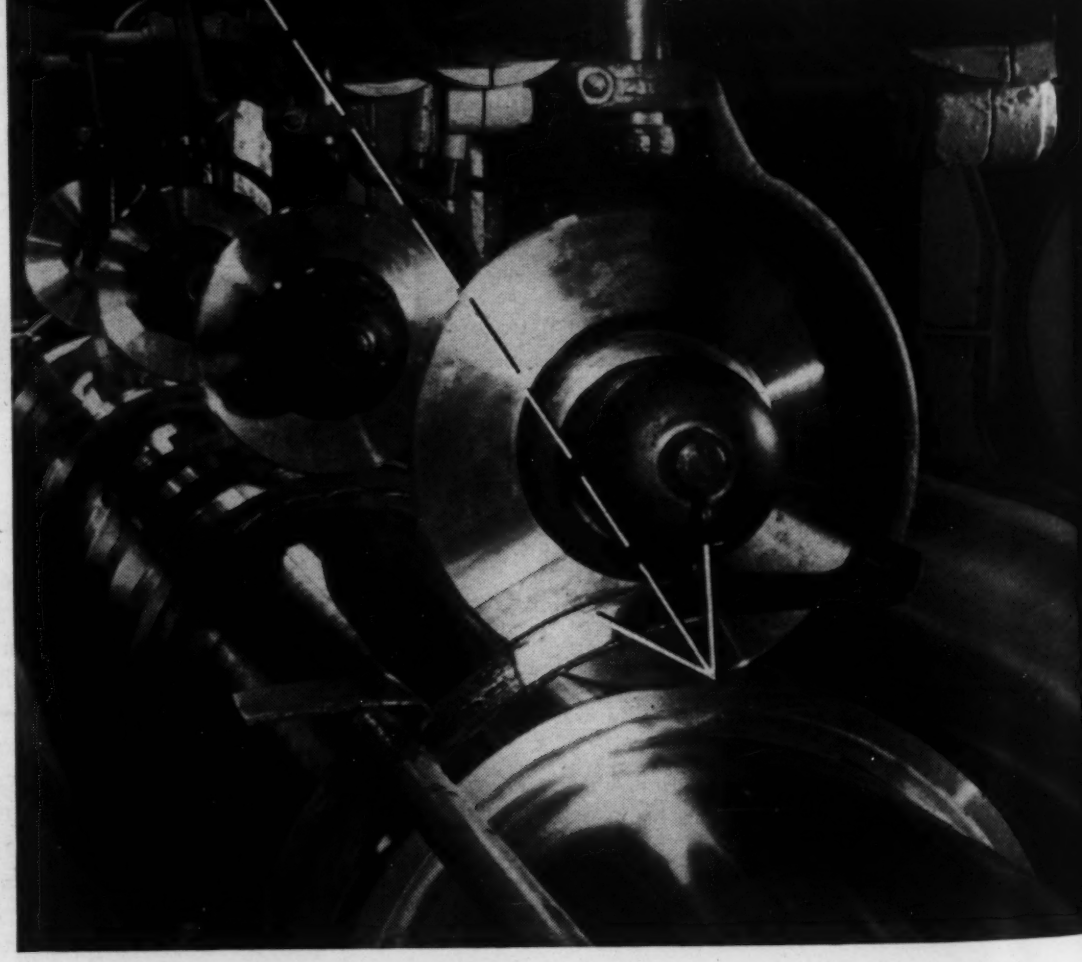
. . . cemented carbide slitters *below which drive steel knives above.*

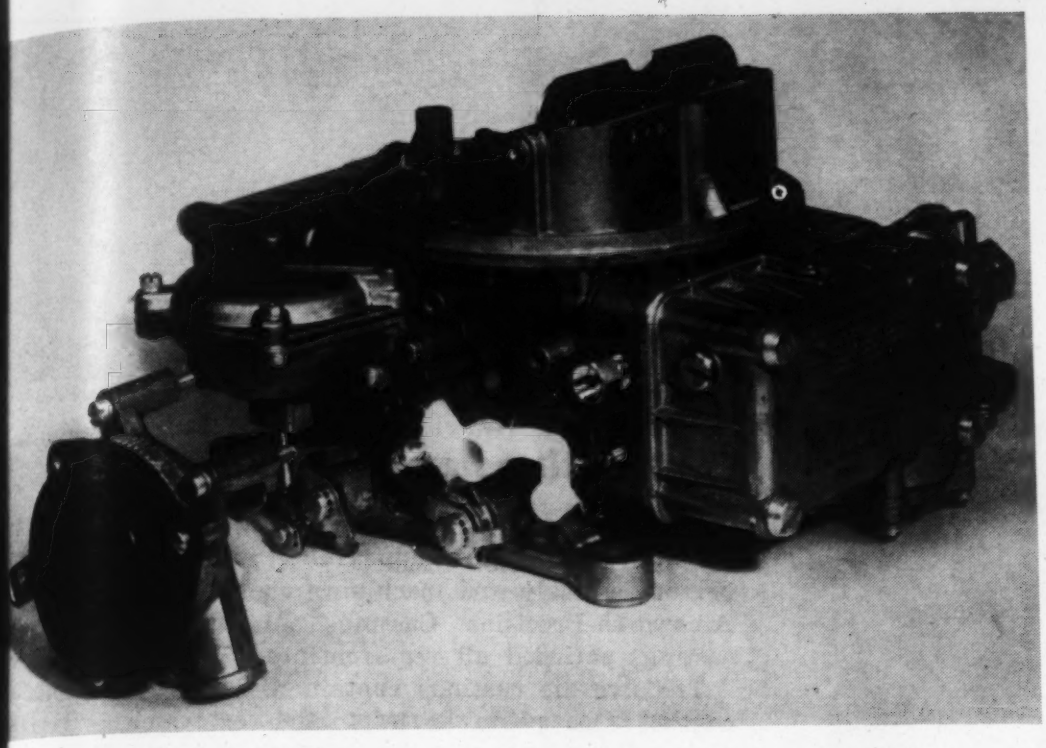
Carbide cutting slitters replace stainless

The change from stainless steel to cemented carbide for the cutting slitters used on paper winding machines has resulted in longer service life, reduced maintenance and improved performance.

As used by Lee Paper Co., each of the paper winding machines contains six steel slitting knives on the upper side of the paper running through the machine (see photo above) and six cemented carbide slitters on the underside of the paper. (Originally, the lower slitters were also made of steel.) As the paper races through the winder at speeds ranging from 1200-2000 fpm, it is cut into strips by the shearing action of the steel knives against the bottom slitters. The top knives, driven by the powered slitters below, are set at an angle of 2 to 3 deg in relation to the bottom slitters and are spring-loaded to provide constant tension. Each knife overlaps its driving slitter by about 3/64 in. (see photo at right).

The previously used stainless slitters lasted only two or three months before regrinding was necessary. The cemented carbide slitters not only have lasted for more than two years, but have increased the life of the steel upper knives: the steel knives are actually being honed and kept sharp in service, with a resultant 50% increase in service life. In addition, when the steel knives operated against steel slitters, they dulled rather quickly, and occasionally small pieces of steel would wear off or break off and become embedded in the paper. This problem has now been completely eliminated.





Molded nylon cam replaces carbon steel

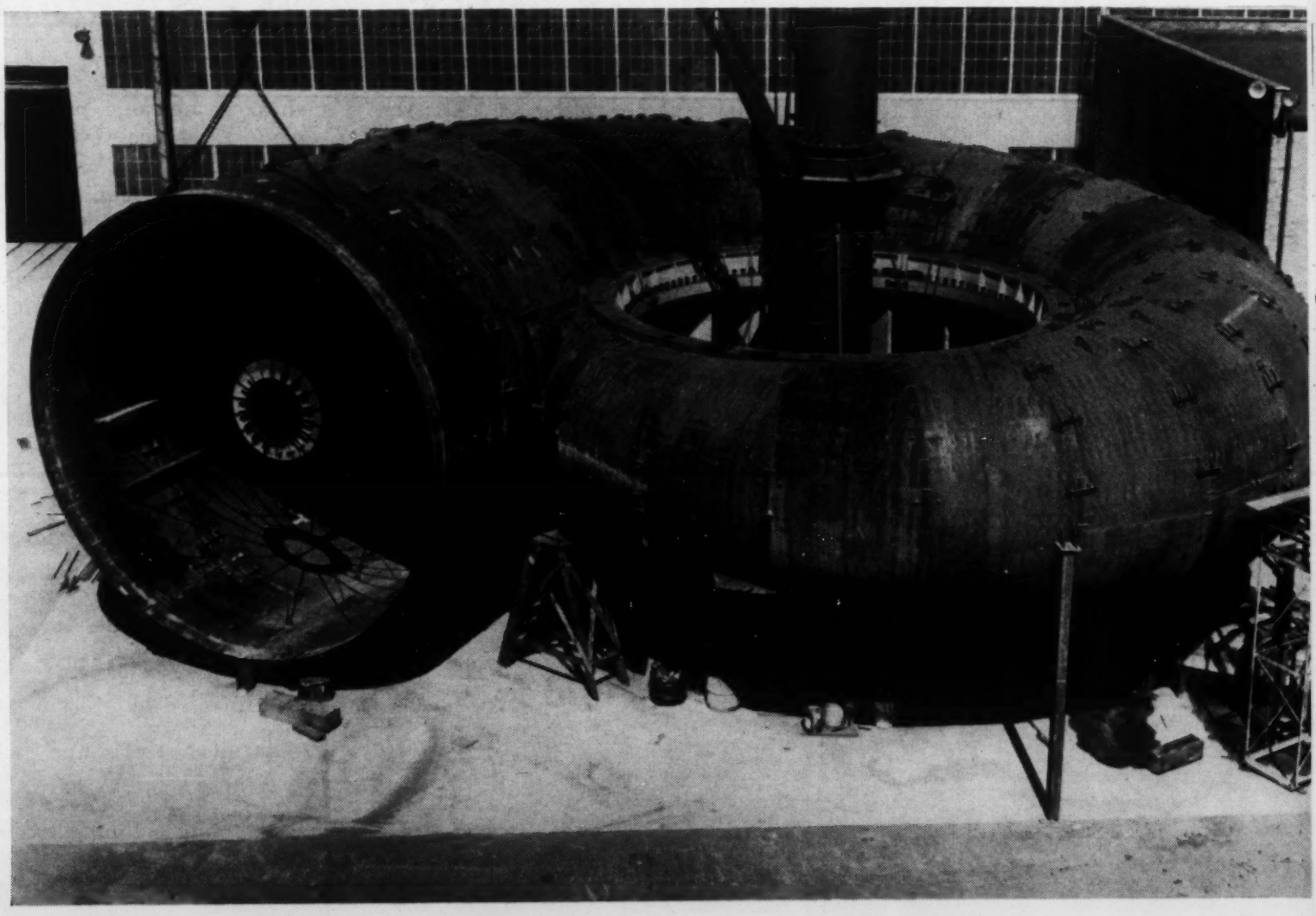
The switch from carbon steel to molded nylon (see photo at left) for carburetor cams used on Edsel automobiles has resulted in lower friction, increased wear resistance, and a 50% saving in manufacturing cost.

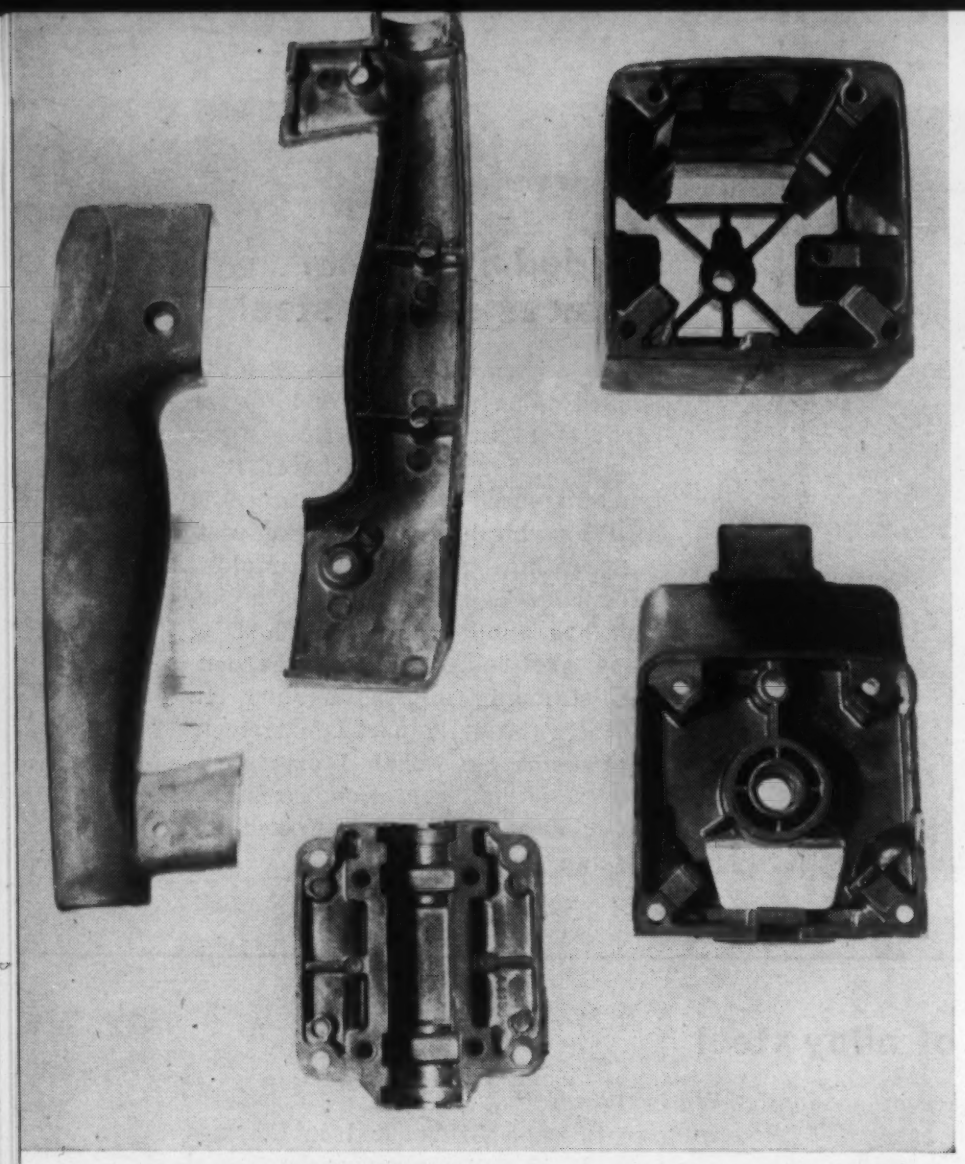
According to Chicago Molded Products Corp., use of the nylon cam has eliminated three finishing steps previously required: hardening, stamping and assembling. In addition, the nylon part is extremely lightweight (less than 1 oz), abrasion resistant, corrosion resistant, self-lubricating and unaffected by oils and grease.

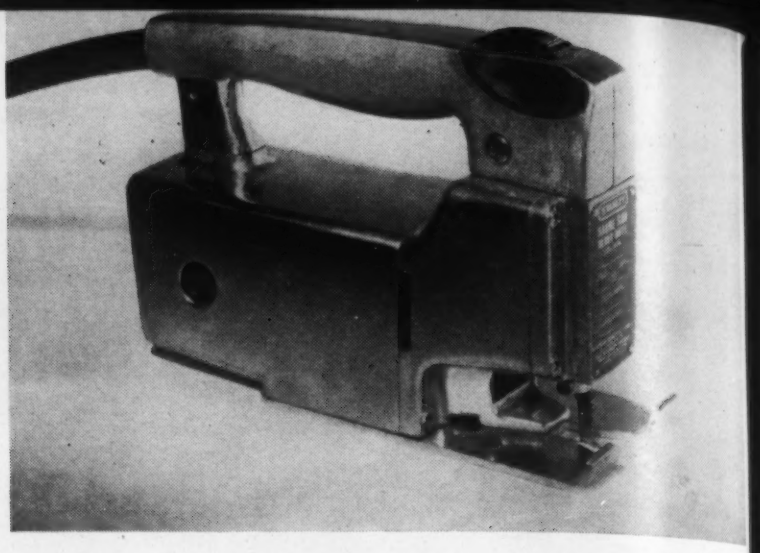
Largest turbine case made of alloy steel

The huge snail-like tube shown in the accompanying photo is actually a turbine scroll case, said to be one of the largest built in the United States. The 24-ft-dia unit is constructed of T-1 alloy steel and will be used in the Noxon Rapids Dam presently being constructed by the Washington Water Power Co.

According to Chicago Bridge & Iron Co., use of T-1 instead of flange-quality carbon steel resulted in a 50% reduction in plate thickness. In addition, the alloy is easily welded and does not require stress relieving.







Die castings used in electric saw

Specifications for the electric saw shown above called for light weight, good appearance, and a minimum number of assembly and machining operations. According to Ainsworth-Precision Castings Co., five aluminum die castings satisfied all requirements.

The five die castings contain a total of 57 points of contact (see photo at left) each of which is held to rigid tolerances to assure perfect fit of parts. To produce the motor housing (upper right) split dies were necessary to meet coring specifications on the bottom of the piece. Stippling on handles was "engraved" right into the die itself.

According to Ainsworth, aluminum was selected in preference to zinc because it is lighter in weight and does not require finishing.

Molded phenolic parts now coated with epoxy

The phenolic camera shown in the photo below has been coated with an epoxy enamel that is said to adhere permanently to molded phenolic parts. The coating is a two-component system based on resin and hardening agents and is applied in a single spray application (see photo on p 192). Cure is obtained by either air drying 10 min at 140 F or baking 1 hr at 250 F.

According to Rextron Finishes, Inc., the development of the epoxy enamel represents a major breakthrough in a barrier that has limited the use of molded phenolic for certain applications. Previously, designers who specified color could not utilize low-cost phenolic even though the material satisfied all other requirements. Now, however, molded phenolic parts can be economically enameled with almost any color for as little as 1¢ per sq ft.

In addition to color and ease of application, the epoxy enamel coating is said to provide a hard, chip-proof, scuff resistant surface. Moreover, the coating can be used with

(Continued on p 192)

Shell Chemical Corp.

MORE MATERIALS AT WORK

Stress relieving with wire.....192

Etched part costs less.....194

Jet engine bearings protected by silicone 194

Extruded steel shape replaces milled bar 196

Aluminum ceiling heats, cools...198

Largest plastics stack.....200

RCI EPOTUF Epoxy Resin

"An ideal resin for potting applications"

says J. R. McRobert, vice president, Novi Equipment Company

Engine heat, vibration and road shocks present problems that must be met and mastered in auto air conditioning equipment. And the Novi Equipment Company, Novi, Michigan, has found that an RCI EPOTUF epoxy resin plays a vital role in the manufacture of its air conditioners — successfully seals a copper coil component in the steel magnetic compressor clutch — insuring dependable performance.

"The use of EPOTUF allows a very close tolerance with a permanent, rigid seal that prevents copper-steel contact — and the 'shorting out' that would thereby result," explains Mr. McRobert. "EPOTUF is the ideal resin for our purposes, possessing excellent qualities of adhesion with the exact electrical properties we require."

Manufacturers everywhere are finding increased use for Reichhold's versatile epoxy resins. EPOTUF epoxies offer rugged strength, corrosion resistance and superior bonding properties that have proven perfect for a variety of applications.

And when you do business with RCI, you can count on fast, on-time deliveries anywhere in the country. Why not let *us* know *your* epoxy requirements?

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Transparent rubber film

To the Editor:

I would like to locate a supplier of a film or sheet rubber which is as close to colorless and transparent (or at least translucent) as possible. Your "File Facts," Dec. '57, included data on two such films, one a PVC-nitrile rubber blend and the other a hydrochloride rubber, but so far I have been unable to determine who produces these films.

JAMES F. MACHEN
Machen Products Co.
Toledo 10, Ohio

Suppliers of PVC-nitrile rubber film include B. F. Goodrich Chemical Co. and Visking Co., Div. of Union Carbide Corp. A producer of hydrochloride rubber films is Goodyear Tire & Rubber Co., Inc.

Specifying heat treatments

To the Editor:

I am interested in obtaining information about recommended practices or standards for specifying the heat treatment of both ferrous and nonferrous metals.

I would greatly appreciate hearing about any publications that would have data on this subject.

J. R. WRIGHT
Development Engineer
Instrument Div.
American Optical Co.
Buffalo 15, N. Y.

Representative sources include SAE Handbook, *ASTM Standards, Steel Castings Handbook,* Metals Handbook. *Any large steel company can furnish additional data books.*

Materials for a reflector

To the Editor:

Your Manual No. 150 "Porcelain Enamels and Ceramic Coatings" in the July issue was of great interest to us. However, we would appreciate information on the following problem.

We are building a prototype specialized test device that requires a 12-in. dia circular, thin metal, spun reflector 5 in. deep. This reflector must have a dead white diffusing reflector surface, such as a coating of magnesium carbonate or similar substance.

We have ovens and other equipment in this plant, and decided we might do this prototype ourselves. The question is how to obtain the flat white matte surface with something that will adhere to the metal spinning.

Will you please help us with information on the material to use or put us in touch with some

Will EPON® RESIN solve that tooling problem?

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In an ever-widening range of production applications, tools and dies made with Epon resin-based formulations are giving outstanding service . . . and providing considerable savings compared to the cost of conventional tooling.

If you are concerned about the high cost of conventional tooling—your tooling resin formulator will show you how to get the most out of durable, impact-resistant Epon resin tools. His skill and knowledge, combined with Shell Chemical's years of experience and research, can mean more profitable production for *you*.

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Excellent tolerances. Little machining and handwork are required to finish Epon resin tools, because the material can be fabricated to very close tolerances.

Outstanding strength. Tools with thin cross sections can be laminated with layers of glass cloth and Epon resin to achieve high flexural strength, and dimensional stability.

Can Epon resin help you with your tooling? Find out now by writing your tooling resin formulator. For a list of tooling resin formulators and further information on Epon resin, write to Shell Chemical.

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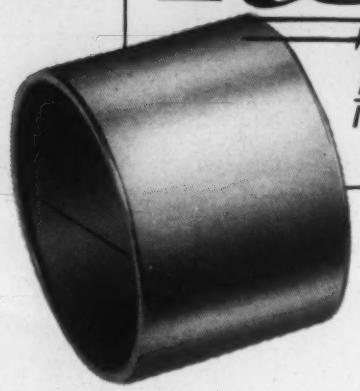
the RULON® T-LINER BEARING



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- unexcelled chemical resistance
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*Dupont's TFE

☐ Send for special sample trial kits: 10 T-Liner bearings of any size of your choice — $8.50.

plastics division: Dixon Corporation
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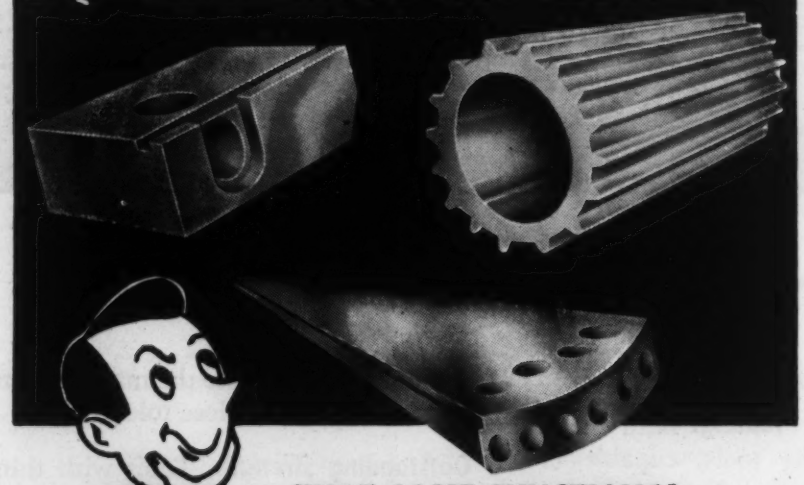
340-8

DO YOU HAVE AN IDEA...



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company that would be interested in such a problem?

The requirements are:

1. The enamel or ceramic must be fairly hard and resistant to normal handling. It will be protected to some extent, and will not be handled except to replace the 1000-w projection lamps.
2. The reflector will not be subject to impact. For shipping, it will be packed in a fiberglass case and protected by rubberized hair padding.
3. It will not be exposed to acids.
4. It will not be subject to bending.
5. It will be subject to heat from projection lamp, but ventilated. Probably 300 to 350° F.
6. It will not be subject to weathering, but will be subject to intense light. It cannot be allowed to yellow.
7. It must withstand the firing temperature.
8. A dead white flat white color and finish are required in order to yield great diffusion of light possible.

ROBERT A. TROIDL
Senior Field Engineer
Systems Development Corp.
Dayton 3, Ohio

Information on aluminum oxide ceramic coatings and matte white porcelain enamel coatings has been forwarded.

Cold welding

To the Editor:

We are interested in cold welding aluminum and/or steel and would like to obtain technical information and also the names of equipment manufacturers and fabricators for the process.

RAYMOND TWIST
Vice President
Mechaneers Inc.
Westport, Conn.

We suggest contacting Utica Koldweld Div., Kelsey-Hayes, Inc., 2409 Whitesboro St., Utica 4, N. Y.

Blow molded polyethylene

To the Editor:

In the July issue of M/DE appeared an article entitled "The New Polyethylenes." One picture shows a piece that has been blow molded. Please send us reprints of articles on this process or sources of information on the details on the process.

R. W. NELSON
Nelson Mfg. Co.
Gaithersburg, Md.

We have no recent articles stressing process details and therefore suggest contacting suppliers listed at end of article.

TABLE 1—ROOM TEMPERATURE PROPERTIES OF SOME AMERICAN STEELS

No.[a]	Designation		Composition, %						Heat Treatment[b]	Mechanical Properties					Reference
	ASTM	Type	C	Mn	Si	Cr	Mo	V		Yld Str, 1000 psi	Ten Str, 1000 psi	Elong (2 in.), %	Red. of Area, %	Impact Str (Charpy), ft-lb	
1[b]	—	1 Mo-¼ V	0.2	0.58	0.26	—	1.04	0.21	1920 F, 4 hr, fc to 1740 F, ac; 1200 F, 4 hr, fc ...	110	140	21	62	—	Rankin & Reich
2	P12[d]	1 Cr-½ Mo	0.15	0.3–0.6	0.3 max	0.8–1.25	0.45–0.66	—	Hot finished, stress relieved 1200-1300 F....	30	60	22	—	69	Ritchings & Crocker
3	P11[d]	1¼ Cr-½ Mo	0.15	0.3–0.6	0.5–1.0	1.0–1.5	0.45–0.66	—	Hot finished, stress relieved 1200-1300 F....	30	60	22	—	69	Ritchings & Crocker
4	P22[d]	2¼ Cr-1 Mo	0.15	0.3–0.6	0.5 max	1.9–2.6	0.87–1.13	—	Hot finished, stress relieved 1200-1300 F....	30	60	22	—	73	Ritchings & Crocker
5[c]	—	1 Cr-1 Mo-¼ V	0.19	0.37	0.12	0.85	1.10	0.25	1920 F, 4 hr, ac.;..... 1200 F, 4 hr, fc	82	134	16	43	—	Rankin & Reich
6	—	1 Cr-1 Mo-¼ V	0.15	0.3–0.6	0.1–0.35	0.8–1.2	0.8–1.1	0.15–0.25	1925 F, 2 hr, ac.;..... 1300 F, 12 hr, ac.	55	85	—	—	12	Ritchings & Crocker
7	TP 347[e]	18 Cr-8 Ni	0.08	0.2 max	0.75 max	17-20	—	—	Optional.....	30	75	35	—	56	Ritchings & Crocker

[a]Numbers used to identify curves in Fig 2 and 3.
[b]fc = furnace cool, ac = air cool.
[c]Test values, others specified minimum values.
[d]A355-55T.
[e]A312-55T; contains also 9-13% Ni, and Cb not less than 10 times carbon content.

Consider Cr-Mo-V Low Alloy Steels for 1000 F Service

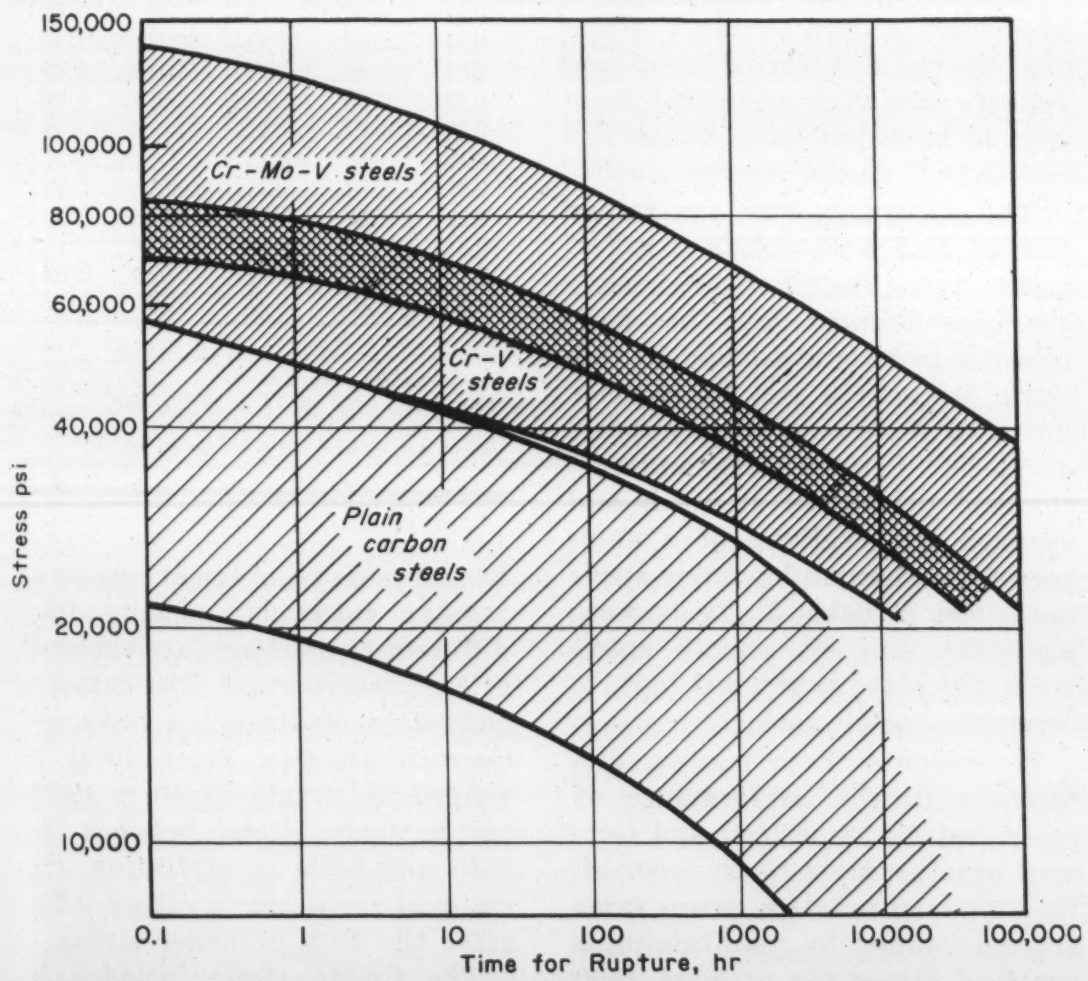

Fig 1—*Stress-rupture properties of carbon, Cr-V and Cr-Mo-V steels at 930 F, based on German work. Cross-hatching indicates overlap of Cr steels.*

This graph

←——shows why

by C. M. Cosman, *Metallurgical Engineer, Vanadium Corp. of America*

■ Demands for industrial equipment to operate economically at ever increasing temperatures and pressures have led to the development of low alloy steels intended for such service. Low alloy chromium-molybdenum steels have been used for power plant service in this country for a number of years. Experimental work has shown that adding vanadium to this type of steel improves high temperature properties. This article compares the long-time properties of chromium-molybdenum-vanadium and other low alloy steels.

As yet, the Cr-Mo-V steels have

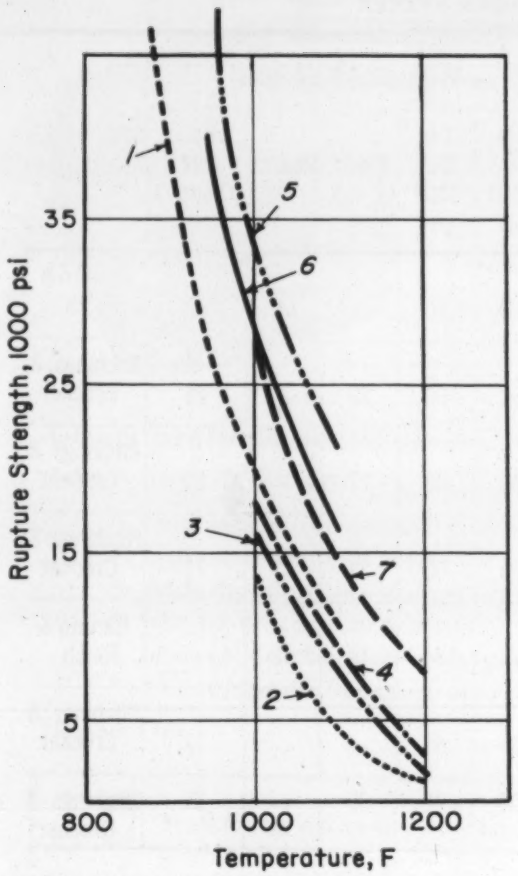

Fig 2—*Stress-rupture properties in 100,000 hr of steels shown in Table 1.*

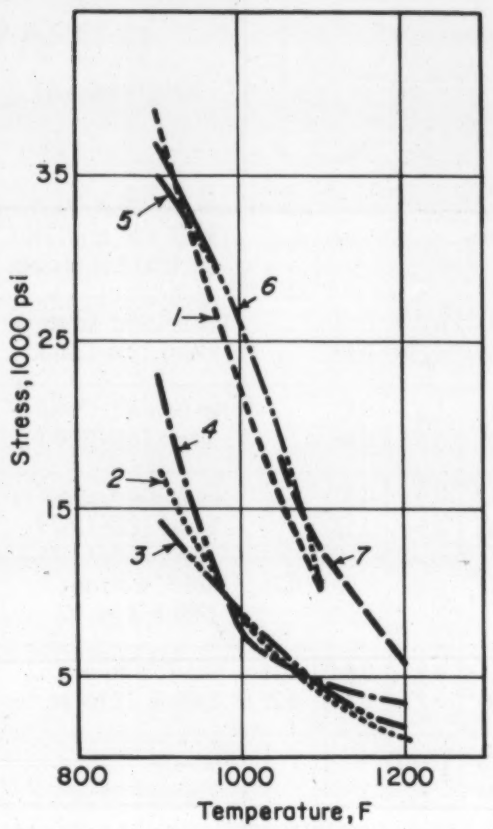

Fig 3—*Creep strength for 1% flow in 100,000 hr of steels shown in Table 1.*

not received the recognition they merit. These steels should be considered not only for power plant service, but also for applications in the chemical and petroleum industries in the 950 to 1100 F range under conditions in which corrosion is not a major problem.

Wrought steels

Compositions and properties of a few steels developed by the U. S. electrical industry are given in Table 1 and Fig 1 and 2. The Cr-Mo steels have been standardized by the ASTM and ASME, but the Cr-Mo-V steels have not yet been standardized.

The creep and stress-rupture properties of the Cr-Mo-V steels are clearly excellent. Creep and rupture data vary somewhat from heat to heat, but these values are considered fairly representative.

The American data are rather limited and were obtained a few years ago. Far more extensive are some German data that have recently become available. In this work, tests were run for periods up to 16 years on a large number of steels. Compositions and mechanical properties at room and elevated temperatures of a number of the German low alloy steels are given in Table 2. Tests were made not only on smooth specimens but also on notched bars to determine notch sensitivity.

To evaluate these results, differences in the performance of creep tests in American and German practice must be understood. In American practice, creep rates are determined by maintaining a constant stress for at least 1000 hr and measuring the extension at regular intervals; usually four different stress levels are explored at each temperature. The data are plotted to obtain creep rates. In German practice, creep limit is defined as a rate of 10 x 10^{-4}% per hr under stress between the 25th and 35th hr of testing, the residual creep not to exceed 0.2% after the 45th hr under stress.

The Cr-Mo steels included in

Composition, %				
C	Si	Mn	P	S
CARBON STEELS				
0.016	0.002	0.024	0.005	0.026
0.13	0.14	0.52	0.044	0.040
0.22	0.24	0.52	0.015	0.015
0.2	—	—	—	—
0.33	0.30	0.64	0.026	0.029
CHROMIUM-MOLYBDENUM STEELS				
0.19	0.32	0.79	0.021	0.022
0.17[a]	0.25	0.39	0.014	0.01
0.32	0.25	0.58	0.015	0.028
0.25	0.25	0.51	—	—
CHROMIUM-VANADIUM STEELS				
0.13	0.83	0.47	—	—
0.14	1.62	0.54	—	—
0.18	0.23	0.53	0.014	0.028
0.25	0.61	0.48	—	—
0.27	0.44	0.56	0.015	0.012
0.27	0.88	0.75	—	—
0.29	0.43	0.53	—	—
0.28	0.39	0.47	—	—
0.27	0.3	0.4	—	—
CHROMIUM-MOLYBDENUM-VANADIUM STEELS				
0.15	0.32	0.056	0.031	0.031
0.21	0.40	0.60	0.011	0.004
0.21	0.82	0.41	0.010	0.010
0.21	0.45	0.33	0.014	0.010
0.22	1.06	0.57	0.015	0.004
0.30	0.27	0.51	—	—
0.19	0.58	0.72	—	—
0.48	0.20	0.70	0.011	0.020
0.22	0.38	0.53	0.01	0.01
0.31	0.37	0.61	—	—
0.32	0.34	0.59	0.091	0.014
0.31	0.36	0.72	0.286	0.016

[a] ac = air cooled; oq = oil quenched; wq = water quenched.
[b] For creep rate of 10 x 10^{-4}% per hr in the 25-35th hr; residual creep must not exceed 0.2% after 45 hr.

Chemical plant: *ever higher temperatures and pressures require constant re-evaluation of materials.*

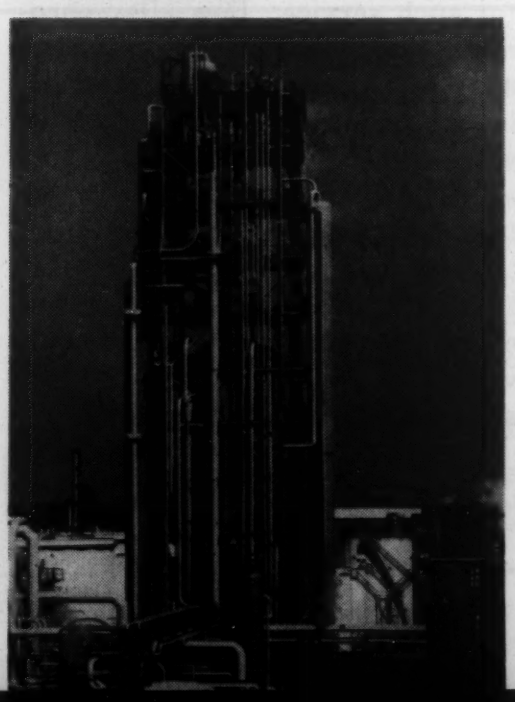

TABLE 2—PROPERTIES OF GERMAN STEELS

Cr	Mo	V	Heat Treatment, F[a]	Mechanical Properties at Room Temperature: Yld Str, 1000 psi	Ten Str, 1000 psi	Elong (5d), %	Red. of Area, %	Creep Limit at 930 F, 1000 psi[b]	Time-Rupture Strength at 930 F, 1000 psi[c]: 1000 Hr S	1000 Hr N	10,000 Hr S	10,000 Hr N	100,000 Hr S	100,000 Hr N	Actual Rupture Testing Time, 1000 hr
—	—	—	Normalized	25-31	42.7	30-36	65-75	5.4	8.7	9.8	5.0	5.8	(2.3)	—	25
—	—	—	Normalized	>32.7	63-65	>25	—	—	12.5	14.9	7.3	8.5	(4.1)	(4.4)	29
—	—	—	Normalized	>37	64-78	>21	—	5.0	11.4	13.4	7.1	7.8	(4.3)	4.6	106
—	—	—	As rolled	—	67-80	—	—	—	19.2	23.5	10.2	12.2	5.0	(5.7)	9
—	—	—	As rolled	57.9	86.9	20.5[d]	54.5	12.8	15.6	17.1	10.0	11.4	6.5	7.5	100
0.68	0.38	—	1050 ac, 1170 ac	70.0	88.6	14	64	23.4	46.8	49.8	32.7	32.7	17.0	17.0	77
0.92	0.56	—	1090 ac, 1290 ac	>43	64.8	>22	—	>22.8	57.5	56.8	52.6	48.3	22.8	21.3	83
0.95	0.26	—	1560 wq, 1120 ac	79.6	97.8	23.2	68	22.8	37.6	52.6	24.2	29.8	16.3	(17.0)	54
1.13	1.11	—	1800 ac, 1180 ac	94.7	112.2	20.2	69.7	36.9	54.0	51.2	35.5	30.6	22.7	17.8	130
1.64	—	0.26	1800 ac, 1290 ac	62.6	88.0	25.5	73	24.2	23.5	26.3	18.5	18.5	14.2	(12.8)	17
1.63	—	0.32	1920 ac, 1380 ac	56.6	84.2	32	74	24-26	22.8	25.6	15.6	12.8	(10.0)	—	13
1.50	—	0.34	1740 ac, 1380 ac	60-61	80-81	22[d]	73	20-21	29.9	33.4	22.0	22.8	16.4	(14.2)	110
1.10	0.03	0.22	1830 oq, 1310 ac	102.4	119.4	20	57	24.9	34.8	29.9	23.5	20.6	17.1	14.2	43
1.17	—	0.46	1720 oq, 1290 ac	112.3	123.6	21.8	72	—	34.1	37.0	22.0	23.5	(12.8)	(14.2)	15
1.45	0.02	0.57	1920 oq, 1330 ac	113.8	128.0	16	60	25	32.0	29.2	19.9	18.5	12.8	11.4	27
1.50	—	0.55	1870 ac, 1330 ac	>71	122.3	>16	—	32.3	41.2	41.2	44.1	38.4	(17.1)	12.8	14
1.26	—	1.03	1920 oq, 1360 ac	103.8	116.6	18.5	66	34.8	41.2	44.1	32.7	35.5	21.3	24.2	37
1.3	—	1.1	1960 ac, 1200-1290 ac	85.3	114-135	>14	—	—	45.5	34.8	35.6	27.0	26.3	(19.9)	51
1.09	0.22	0.22	1760 oq, 1290 ac	93.1	107.6	21	66.5	21-23	45.5	48.3	39.1	24.9	(30.6)	—	22
1.10	0.68	0.07	1600 oq, 1310 ac	83.5	99.7	17.9[d]	72.8	37.0	40.5	46.2	25.6	32.0	17.8	(21.3)	32
1.10	0.77	0.11	1600 oq, 1260 ac	101.1	113.9	16.0[d]	69.8	45.5	51.9	58.3	41.2	42.7	29.2	27.0	89
1.00	1.01	0.07	1740 ac, 1290 ac	105.2	119.4	12.5[d]	65.2	56.9	65.4	49.8	44.1	34.1	28.4	—	38
1.11	1.30	0 15	1600 oq, 1180 ac	109.5	127.4	10.9[d]	56.3	50.0	49.8	55.5	36.3	39.8	24.9	28.4	49
1.61	1.28	0.10	1740 ac, 1260 ac	105.2	129.4	18.8[d]	65	44.4	49.8	55.5	37.0	34.8	26.3	21.3	140
0.95	0.73	0.21	1740 oq, 1200-1240 ac	>85.3	114-135	>15	—	56.9	64.0	49.8	46.9	34.1	29.9	25.6	35
2.31	0.42	0.26	Treated	110.9	162-185	—	—	48.3	58.3	61.1	45.5	39.8	(32.7)	—	20
1.62	0.43	0.39	1740 oq, 1260-1270 ac	—	114-119	—	—	49.8	45.5	51.2	32.7	33.4	23.5	18.5	120
2.58	0.26	0.48	1560 wq, 1110 ac	—	176.3	16.4	60	27.3	50.5	50.5	27.7	27.7	14.9	14.9	125
2.82	0.30	0.45	1560 wq, 1110 ac	>142	156-185	>12	—	—	58.3	59.7	32.7	29.2	—	—	18
2.32	0.33	0.43	1560 wq, 1110 ac	>142	156-185	>12	—	—	45.5	56.9	27.7	34.8	—	—	21

[c]Strength based on initial cross section at room temperature. Extrapolated values in parenthesis. S = smooth, N = notched test pieces. Notch: 60 deg; depth of 10%; radius at base 1.66% dia of test piece.
[d]Length = 10 d.
[e]Also 0.35% Ni.
Source: A. Thum and K. Richard.

Table 2, in conjunction with those in Table 1, will give the engineer a basis for judging the properties of the other steels included in the German work.

Some stress-rupture strength bands for plain carbon, Cr-V and Cr-Mo-V steels based on German determinations (including tests as long as 140,000 hr in some cases) are shown in Fig 3. The outstanding performance of the Cr-Mo-V steels shows up clearly.

In addition to the steels given in Table 2, many others have been tested, among them compositions now recognized as completely unsuited for service at 900 F.

Cast steels

The influence of nickel on the high temperature behavior of steel has been the subject of considerable discussion. In high temperature castings of the Cr-Mo-V or Cr-Mo types, nickel was believed to favor embrittlement. This effect has been re-examined in some recent Swiss work and reported by *Felix*, who compared Cr-Mo and Cr-Mo-V steel castings with and without nickel. Compositions are shown in the notes to Fig 4. The steels were oil hardened from 2012 F and tempered 6 hr at 1330 F; both smooth and notched test pieces were tested at

Why New Steels Were Developed

Operators of steam power plants are continually aiming to attain higher operating temperatures and pressures with correspondingly greater operating efficiency. For example, the average power station in the United States consumed 6.5 lb of coal per kw-hr of generated power in 1902, and the best used 3.5 lb; in 1957 the respective values were 0.93 and 0.75 lb. Over the same period, throttle steam temperature of the most modern equipment rose from 450 F to about 1100 F.

As steam temperatures and stresses increased, designers met the materials problem initially by using standard materials and increasing the thickness of stressed parts; later they specified high alloy steel compositions. Cost considerations led to the development of economical low alloy steels, and such steels as the Cr-Mo and Cr-Mo-V types were proposed.

Service tests indicate the difference in behavior between carbon and low alloy steels becomes particularly noticeable at temperatures exceeding 1000 F. In the early '30s, a 10,000-kw turbine was operated for almost three years (26,453 hr) at a steam temperature of 1000 F; upon examination after completion of the test the parts were found generally in good condition, with small creep movement. Subsequently, tests were performed under 380 psi steam pressure at 925 and 1100 F for 400 to 1600 hr. Weight losses and hardness, metallographic features and corrosion trends were determined on a wide range of steel compositions. At 925 F carbon and alloy steel exhibited only slight differences, but at 1100 F there were marked differences: corrosion of the carbon steel was a constant function, increasing in severity with time, whereas the alloy steels showed ultimately a decreasing rate of corrosion.

Some years later, as the result of a steam line service failure at the Springdale power station near Pittsburgh, it was found that aluminum-deoxidized fine-grained steel has a tendency to precipitate graphite in the zone subjected to heat penetration caused by welding, precipitation occurring after exposure to temperatures above 900 F for over 10,000 hr. Although the mechanism underlying this behavior is still not completely understood, means of correction have been developed. Effects of aluminum deoxidation can be counteracted by the addition of suitable amounts of vanadium, chromium or both. Low alloy steels containing 1.0 chromium, 1.0 molybdenum and 0.25% vanadium, or 1.0 chromium, 0.50 molybdenum and 0.25% vanadium appear to be immune to graphite formation at high temperatures and to offer excellent possibilities for service.

1020 F. The test ran up to 20,000 hr without showing any unfavorable effect from the nickel content in a range of 0.5 to 1% nickel.

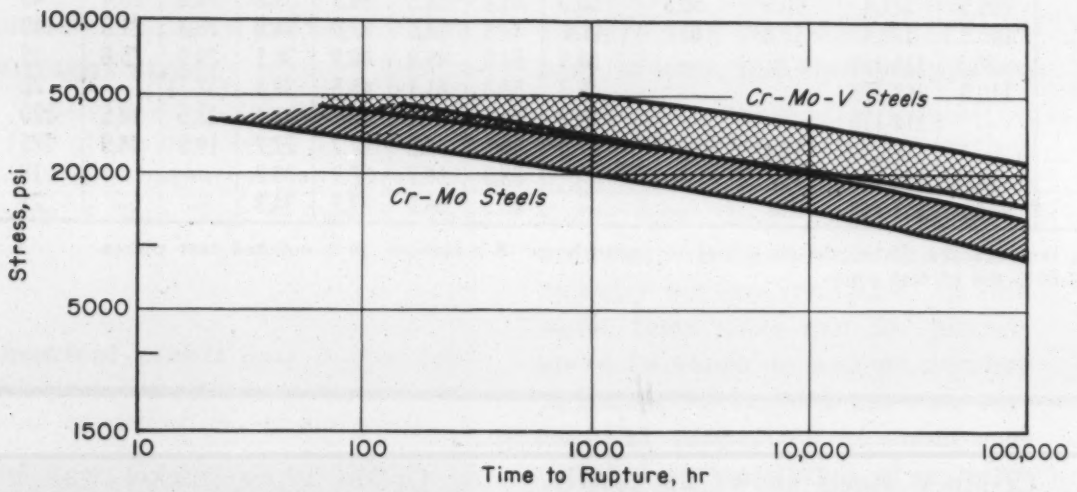

Fig 4—*Stress-rupture properties of cast Cr-Mo and Cr-Mo-V steels at 1020 F.*

COMPOSITION OF CAST STEELS:

C	Si	Mn	Cr	Mo	Ni	V
Cr-Mo Steel Castings						
0.11	0.34	0.50	0.67	0.87	tr	tr
0.12	0.35	0.53	0.52	0.83	0.22	tr
0.11	0.40	0.63	0.54	0.88	0.54	tr
0.12	0.37	0.62	0.57	0.82	0.81	tr
0.11	0.44	0.56	0.54	0.90	1.55	tr
Cr-Mo-V Steel Castings						
0.11	0.34	0.55	0.64	0.82	tr	0.25
0.10	0.47	0.55	0.54	0.83	0.49	0.24
0.11*	0.43	0.64	0.52	0.83	0.62	0.24

* Also 0.36% Cu.

Fig 4 shows the superior performanance of the Cr-Mo-V steels investigated by Felix. These values are for smooth test pieces. Notched Cr-Mo specimens gave slightly better values than the smooth test pieces; linear extrapolation indicated a 100,000-hr rupture strength of 8500 psi at 1020 F.

For Cr-Mo-V steels, the performance of unnotched and notched test pieces was in much closer agreement. The 100,000-hr rupture strength for the Cr-Mo-V steels is about 15,000 psi at 1020 F.

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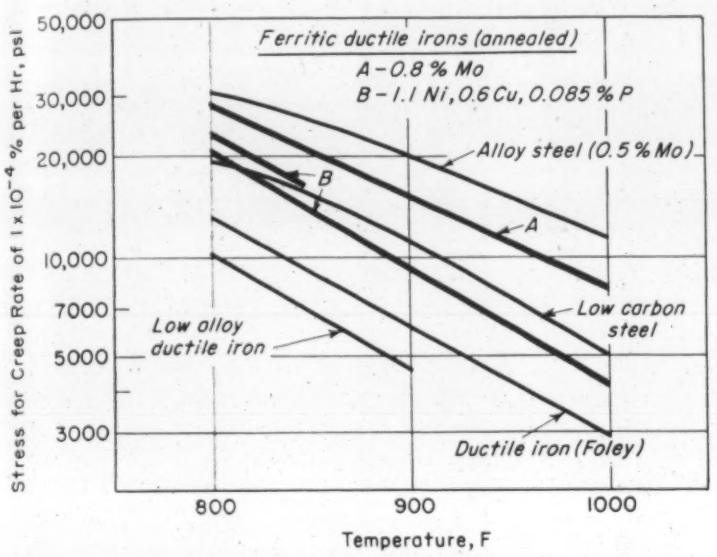
Alloy Ductile Irons

Promise Better High Temperature Strength

A report on several experimental alloys

FERRITIC IRONS ↓



Creep up to 1000 F is shown for a molybdenum iron (A) and a nickel-copper iron having a phosphorus content higher than normal (B).

At 800 F and 25,000 psi, iron A starts third-stage creep after about 1600 hr, indicating that the safe working load would be somewhat less than 25,000 psi for stable long-time service. An iron containing less molybdenum (0.24% instead of 0.8%), though less creep resistant than iron A, nevertheless had twice the creep strength of low alloyed irons.

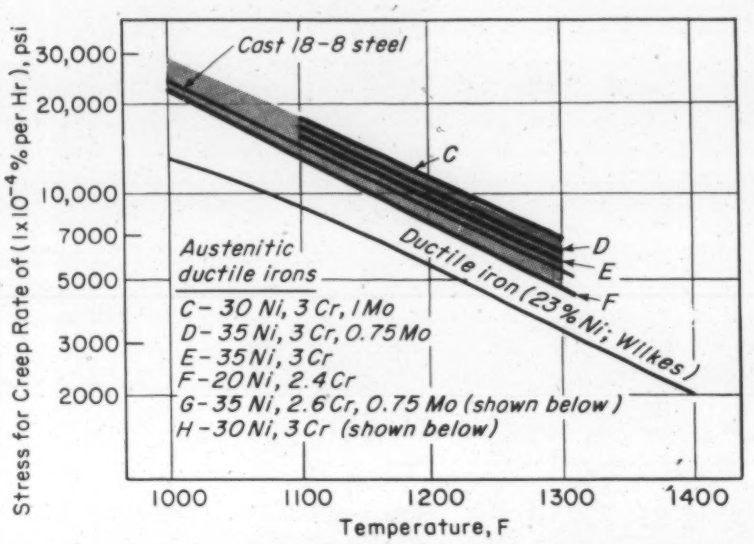
Creep behavior of iron B represents a 2½-fold improvement over low alloyed irons. Third-stage creep started after 3500 hr at 800 F; stress-relieved specimens had slightly higher creep strength than the annealed specimens represented here and had not entered the third stage of creep after 5650 hr. At 600 F (not shown) small amounts of first-stage creep occurred at 30,000 and 40,000 psi, but creep rates were essentially zero after about 1800 hr; thus yield strengths were more significant than creep at 600 F.

Results of other tests on iron B: Stress to produce rupture in 1000 hr was 27,000 psi at 800 F, 7500 psi at 1000 F. Short-time ultimate strength was 70,000 psi up to 600 F, then decreased to about 35,000 psi at 1000 F. Short-time yield strengths diminished more gradually—from 55,000 psi at room temperature to 32,000 psi at 1000 F.

Work on alloys similar to *B* showed that creep resistance can be significantly improved by keeping the phosphorus content of ductile iron at about 0.09% instead of the customary lower level. Ductility is not excessively impaired.

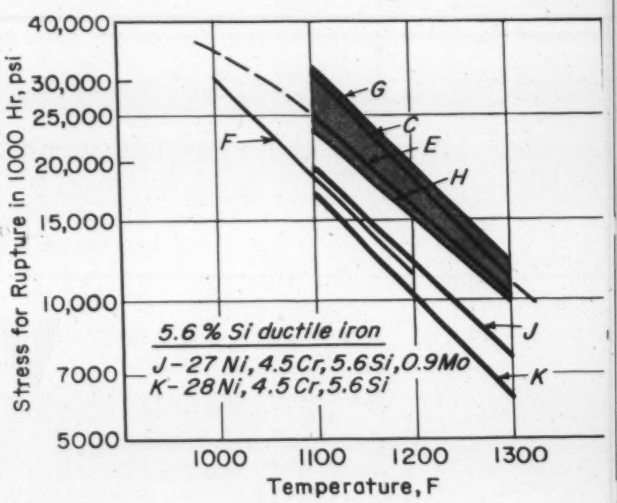
Adapted from a paper by R. D. Schelleng and J. T. Eash, Research Laboratory, International Nickel Co., Inc., given before the American Society for Testing Materials, June '57.

AUSTENITIC IRONS ↓



Creep up to 1300 F is shown for two nickel-chromium (E, F) and two nickel-chromium-molybdenum (C, D) irons. The molybdenum-containing irons have the higher creep strength. Note similarity to creep properties of cast 18-8 stainless steel.

Stress - rupture to 1300 F is shown for five nickel - chromium and nickel-chromium - molybdenum irons (C, E, F, G, H) and two similar irons containing 5.6% silicon.

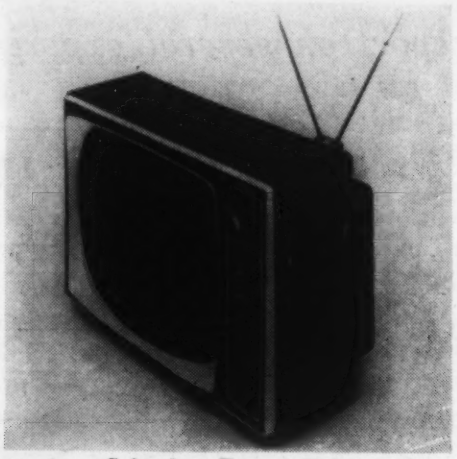


The molybdenum-containing irons have the higher stress - rupture strength in both cases. At 1100 F, adding 0.7-1% molybdenum to nickel-chromium irons raises 1000-hr rupture stress by 6000 psi. Raising nickel content from 30% to 35% provides another increase of 1500-2000 psi.

Results of other tests on iron F: Short-time ultimate strength decreased gradually from about 60,000 psi at room temperature to 48,000 psi at 800 F, then fell off to 20,000 psi at 1400 F. Elongation increased from 10% at room temperature to 15% at 1400 F.

In alloys J and K, silicon content has been boosted to 5.6% instead of the customary 2%. These silicon-containing irons would have much better corrosion resistance than the other irons but, as shown here, they have considerably lower 1000-hr rupture strength in the 1100-1300 F range.

Here are some of the newer uses for vinyl-metal laminates . . .



Columbus Coated Fabrics Corp.

Columbus Coated Fabrics Corp.

Arvin Industries, Inc.

***Electrical products**—This GE television cabinet, Motorola radio housing, and Arvin electric heater screen are typical applications of vinyl-metal laminates in electrical equipment. The laminates have also been used to decorate and protect exteriors of air conditioners, business machines, dehumidifiers, dictating and vending machines, refrigerators and phonographs.*

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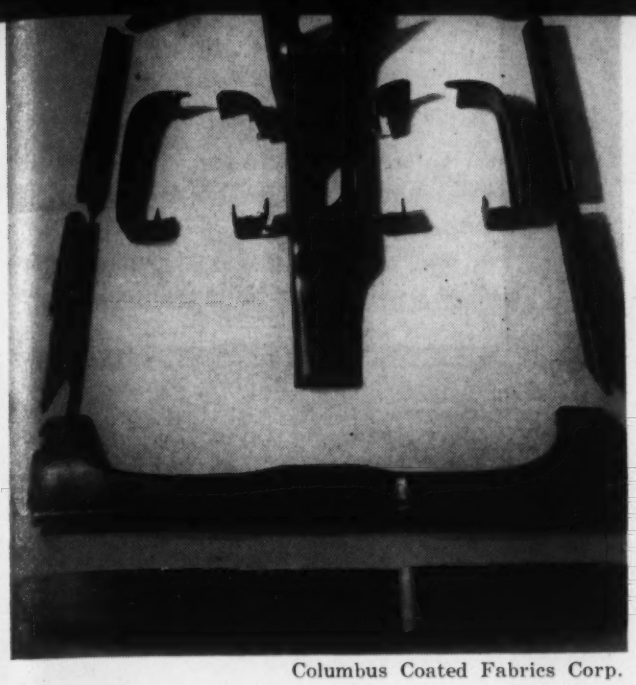
by Robert J. Fabian, *Associate Editor, Materials in Design Engineering.*



Columbus Coated Fabrics Corp.

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Masland Duraleather Co.

Transportation equipment *The photo at top left shows the extensive use of laminates in the interior of the 1958 Ford Thunderbird. Illustrated are the console panel, instrument panel extensions, window garnish moldings, seat side shields, bucket seat moldings, package tray and tray covers. Bottom left is the vinyl-metal cabin paneling of the new Boeing 707 jet transport which combines decorative appeal with high strength and resistance to marring. Photo above shows how a vinyl-metal laminate is used on deck of new aluminum outboard motorboat. Note use of matching trim on seat cushions.*

■ The development of new applications for vinyl-metal laminates appears to be limited only by the imagination of the designer. Starting from a few experimental products just a short time ago, applications have developed so rapidly that it is hard to keep abreast of new developments. The purpose of this article is to give the designer an up-to-date report on laminate properties, useful design and fabrication data, and some suggestions as to where vinyl-metal laminates can be used to advantage.

Properties of laminates

Appearance — Probably the most noteworthy charactertistic of vinyl-metal laminates is their outstanding appearance. As shown in the accompanying photographs, vinyl laminates enable the designer to obtain a whole new variety of finishes that could not be obtained previously. The number of textures and colors that can be produced is almost unlimited. Typical of the textures now being produced are leathers, textiles, wood grains, high gloss metal finishes, non-reflecting matte finishes, and marbleized finishes. Many of these finishes are produced by photographic techniques and can be distinguished from original surfaces only after a very close inspection. The leather finishes, in particular, are so authentic that in some cases they can only be detected by smelling the material. About the only finish that cannot currently be produced is a highly polished one.

All of the available textures can be produced in just about any color. Resistance to fading depends on the pigments used. Almost all colors have outstanding fading resistance for interior ap-

PROPERTIES OF VINYL LAMINATES

PHYSICAL AND MECHANICAL PROPERTIES	
Specific Gravity (vinyl)	1.33 to 1.38
Max Rec Svc Temp, F	200
Dielectric Strength, v/mil	900
Moisture Absorption (ASTM D570)	Negligible
Volatility Loss (ASTM D1203-52T), %	.1 (max)
Abrasion Resistance[a], % wt loss	0.1

CHEMICAL RESISTANCE	
15% Hydrochloric Acid (150 F, 30 days)	OK
25% Phosphoric Acid (150 F, 30 days)	OK
15% Sulfuric Acid (150 F, 30 days)	OK
Chromic Acid (150 F, 30 days)	OK
10% Acetic Acid (150 F, 17 days)	OK
10% Lactic Acid (150 F, 17 days)	OK
Ethanol (150 F, 17 days)	Sl shrinkage
Mineral Oil[b] (210 F, 70 hr)	Sl loss in elong but no swelling
10% Caustic Solution (150 F, 30 days)	OK
Distilled Water (150 F, 30 days)	OK
Alcohols (70 F, 14 days)	OK
Carbon Tetrachloride (70 F, 1 day)	Severe swelling
Ketones (1 day)	Severe swelling and dissolving

[a]Fed Spec L-P-406B, Method 1091.1, 1000 revolutions, 1000-gm load, CS-17 wheel.
[b]ASTM oil No. 3.

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Luggage and carrying cases *Use of vinyl-aluminum and vinyl-magnesium laminates provides an extremely durable and attractive structure for luggage and gun cases. Similar laminates have been used for musical instrument and typewriter cases, and for fishing tackle boxes.*

Masland Duraleather Co.

plications. However, some colors (pastels in particular) fade quite badly when used outdoors. Many tests are currently being conducted on fading resistance and if there is any question on this point the laminate producer should be consulted.

Chemical resistance—The high molecular weight polyvinyl chloride resins used in vinyl laminates are inherently chemically stable. However, some types of vinyl films are given a clear protective coating of up to 2 mils for added resistance to corrosion, staining, abrasion and handling. The resistance of coated vinyl laminates to a number of severe chemicals is shown in the accompanying table. In addition to these chemicals, vinyl laminates are not stained or otherwise affected after 48-hr exposure to such common media as petroleum, alkalis, citric acid, Clorox, ammonia, milk, animal oil, vegetable oil and greases.

Vinyl laminates have also successfully withstood overnight exposure to lemon and orange peel, coffee, tea, banana peel and ketchup. Some staining, however, has been encountered with vinegar, spinach, red food dye and mustard. Laminates can also be damaged by lacquer solvents and chlorinated solvents; however, these materials would not nor-

How Laminates Are Made

Vinyl-metal laminates are produced in six basic steps: 1) metal preparation, 2) application of adhesive, 3) solvent evaporation, 4) heat reactivation, 5) vinyl application, and 6) cooling.

Metal preparation usually consists of treatment in an alkali cleaner followed by the application of an amorphous chemical conversion coating to promote adhesion. A phosphate or chromate conversion coating is used, depending on the base metal.

After the conversion coating is rinsed and dried, a thermosetting adhesive containing organic solvents is applied by spray or roller coating. For ultimate bond strength the adhesive must be applied in a smooth coat at a dry film thickness of 0.3 to 0.7 mil.

After the solvents are evaporated the adhesive is activated by heating it to 375 to 410 F. As soon as this temperature is reached the vinyl sheeting is applied by roll pressure at about 25 to 60 psi. After the film is bonded to the metal the laminate is quickly cooled with a water bath or spray to a temperature below 150 F to prevent damage to the vinyl.

Composition of the vinyl film is of vital importance in the production of laminates. A semi-rigid quality vinyl is generally used. Also, it is particularly important that the optimum amount of non-migratory plasticizer be used; sufficient plasticizer must be present to make the sheet flexible enough to withstand drawing and forming operations.

Household products *Vinyl-metal laminate on this Samsonite table top is decorative and resistant to marring, burning and staining. These properties are also used to advantage in such diverse household products as wastebaskets, food and drink coolers, food trays, clothes hangers, and folding chairs.*

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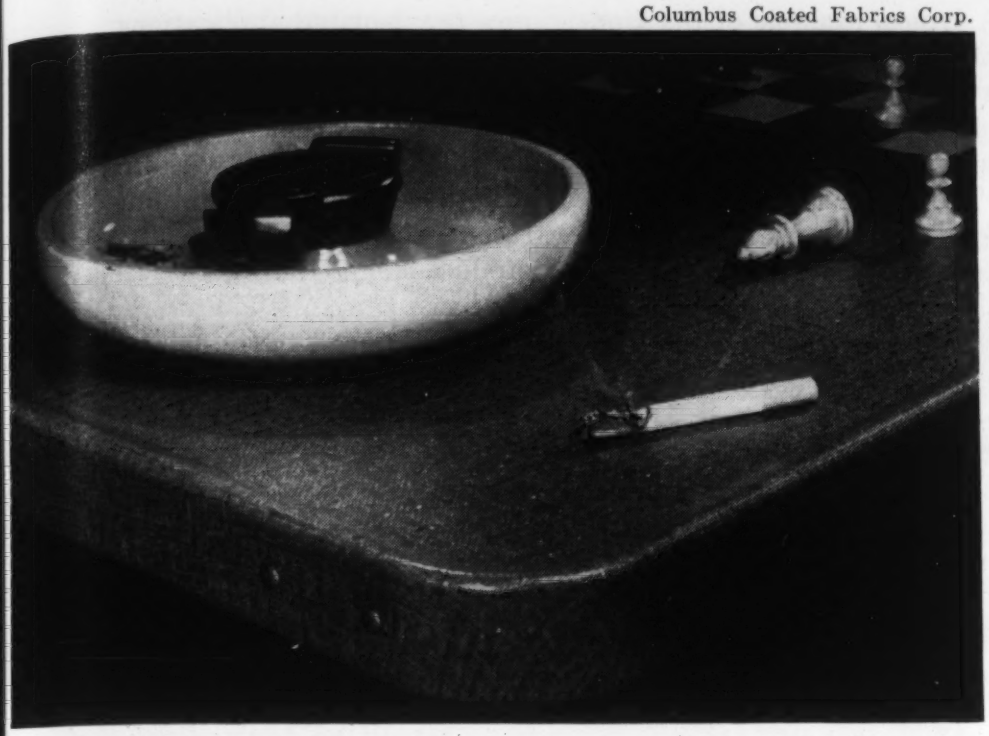

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Building applications *This Brussels theater ticket booth typifies the widespread use of vinyl-metal laminates for outdoor applications in Europe. Similar laminates have been used on store fronts and counters, wall paneling, office partitions, and doors and cabinets.*

mally be encountered in service.

Generally, the exposed edges of laminates do not present any corrosion problem. However, if severe corrosion is expected edges can be protected with a cadmium or zinc plate or a vinyl-base paint. The vinyl paint will not support combustion but is susceptible to staining by dyes, nicotine and some foods.

Moisture and weather resistance—Vinyl-metal laminate panels have been exposed for 1000 hr to 100% RH at 160° F with no sign of adhesion failure or blistering. Also, laminates exposed to intermittent water spray at ambient temperatures have shown no deterioration after one year; wherever minor absorption did occur it caused only a slight color change and loss of gloss.

Laminates have successfully withstood prolonged exposure to industrial atmospheres and accelerated weathering tests. Some laminates have a tendency to lose reflectance and to chalk and discolor slightly after exposure. Consequently, the laminate supplier should be consulted before selecting a laminate for a particular outdoor application. An indication of just how well laminates can perform outdoors is the fact that they have been successfully used on store fronts for several years and are now being used for exterior building sheathing in Europe.

Abrasion and wear resistance—Vinyl-metal laminates have outstanding abrasion and wear resistance. This has been demonstrated by the successful use of laminates in luggage, television and radio cases, and flush doors. In addition to the data cited in the table, wear tests using a Taber Abrader (CS-10 wheel) have shown that it takes over 2,000 revolutions to wear through 1 mil of a vinyl laminate.

Heat resistance—In general, the maximum recommended operating temperature of vinyl laminates is about 200 F. Vinyl-metal laminates have shown no loss of adhesion and no tendency to delaminate after exposure to 150 F for 600 hr. Laminates exposed to 210 to 250 F will not show any surface change unless some pressure is applied to the surface while it is hot.

Available forms

In general, any ferrous or nonferrous base metal can be used in a vinyl-metal laminate. However, the three most common metals in use today are cold rolled steel, aluminum and magnesium. A steel base is usually selected where strength and low cost are dominant design factors. Aluminum is used where lightness and/or corrosion resistance is required. Magnesium is usually used only where extreme lightness is required (e.g., luggage and carrying cases).

Any of these base metals can be laminated with vinyl on one or both sides. Ordinarily, a single side laminate is sufficient for product exteriors. However, a double side laminate may be required if the reverse side of the part must have special properties. For example, luggage is sometimes provided with a vinyl layer on the inside for appearance and added durability. Also, television cabinets have been provided with a vinyl interior layer to provide electrical insulation.

The reverse side of a laminate can also be provided with a wide variety of organic finishes or electroplates. The type of finish selected depends on the end use of the product. For added decorative appeal and resistance to rust and corrosion, reverse sides of steel laminates can be readily plated with zinc, chromium, copper, cadmium or nickel without damaging or discoloring the vinyl layer. An example is the reverse side of the small portable radio shown on page 98 which has been zinc plated.

A vinyl film of 10 to 15 mils has proved quite satisfactory for most applications. However, films as thin as 4 mils and as thick as 25 mils and higher are available if required. Thickness of the base metal depends on the structural requirements of the application. The practical laminating thicknesses for steel are 0.012 to 0.06 in., for aluminum 0.016 to 0.125 in., and for magnesium 0.016 to 0.081 in. Sheets are available in sizes up to 52 x 120 in. and larger. Also, coil stock in 40-in. widths is available in almost any desired length.

Shaping the laminate

Drawing and forming—Existing dies can be used to deep draw or die-form a vinyl-metal laminate if the gage of the metal is reduced to compensate for the added thickness of the vinyl. Usually a reduction of one gage in metal thickness is adequate, since the vinyl will compress up to 40% during forming. For example, if the capacity of an existing die is 20 ga. (0.036 in.) it will accommodate a laminate with a metal thickness of 22 ga. (0.030 in.), which is the next lightest gage. This means that the vinyl can be compressed to a minimum thickness of 0.006 in. during forming. Thus, the maximum thickness of the vinyl that can be used in the laminate is 0.010 in. (0.010 in. x 60% = 0.006 in.).

The maximum draw that can be obtained is generally limited by the forming properties of the base metal. Draws that can be made in one operation are satisfactory. However, it is not possible to anneal the metal and redraw. Corner radii on draws should be large enough to permit satisfactory drawing without tearout. A typical example of the kind of draw that can be produced is a part of 22-gage steel with a 0.014-in. vinyl layer which can be successfully drawn to a depth of 4 in. The corner radii in this case are ¼ in., and the maximum area at the upper end of the draw is 4⅛ x 3⅝ in.

Any standard lightweight die lubricant may be used; however, water-soluble or silicone-base lubricants are recommended. Slip sheets of heavily waxed paper have also been used successfully. An unleaded gasoline, mild detergent or power spray wash is recommended for removing any heavy grease on the laminate. Trichloroethylene vapor degreasers or chlorinated solvents are not recommended because of their adverse effect on the laminate bond.

Other shaping operations—In general, vinyl-metal laminates can be processed on all standard metal forming machines. Typical forms that can be obtained include a Pittsburgh lock, a 90-deg crimp bend, a 180-deg bend, a double Ogee roll, and a crimp roll. In addition, some metal spinning operations can be performed with aluminum laminates.

A vinyl-metal laminate will withstand normal cutting and shearing operations without damage. Whenever possible the vinyl side of the laminate should be exposed to the cutting edge or shearing blade of the tool. (Burring of the vinyl can occur if it is placed away from the cutting edge.) When shearing a double vinyl laminate, the side of the laminate with the thinner vinyl film should be away from the shearing or cutting edge.

Fastening the laminate

Mechanical fastening — Vinyl-metal laminates can be readily fastened with conventional sheet metal screws, bolts, rivets, lock nuts and speed nuts through drilled or pierced holes. They can also be fastened by standard crimping and lock seaming methods. In general, brazing and soldering do not produce very strong joints and are used only in a few isolated applications.

Welding—One of the most significant developments in vinyl-metal laminates is that they can now be fastened by welding. A resistance welding technique has recently been developed which can produce a high strength weld on the back of a steel laminate without indenting or burning the vinyl or affecting its bond. The new technique involves indirect projection welding with a magnetic force-type resistance welding machine. It has proved to be the only really satisfactory method for welding studs, reinforcing ribs, brackets, etc.

Welding is accomplished by using two copper alloy electrodes that contact the work pieces from the same side. One electrode contacts the piece to be welded which is placed against the back of the vinyl-clad sheet, and the other electrode contacts the steel back of the vinyl-clad sheet itself. In this way the current passes from one part to the other without passing through the vinyl cladding and without either electrode touching the vinyl.

The magnetic force-type resistance welding machine differs from other resistance welding machines in that the pressure, or welding forging force, is activated electrically rather than mechanically. Electrical activation permits a very short weld time, or heat-on period, which is perfectly synchronized with the forging force.

Acknowledgments

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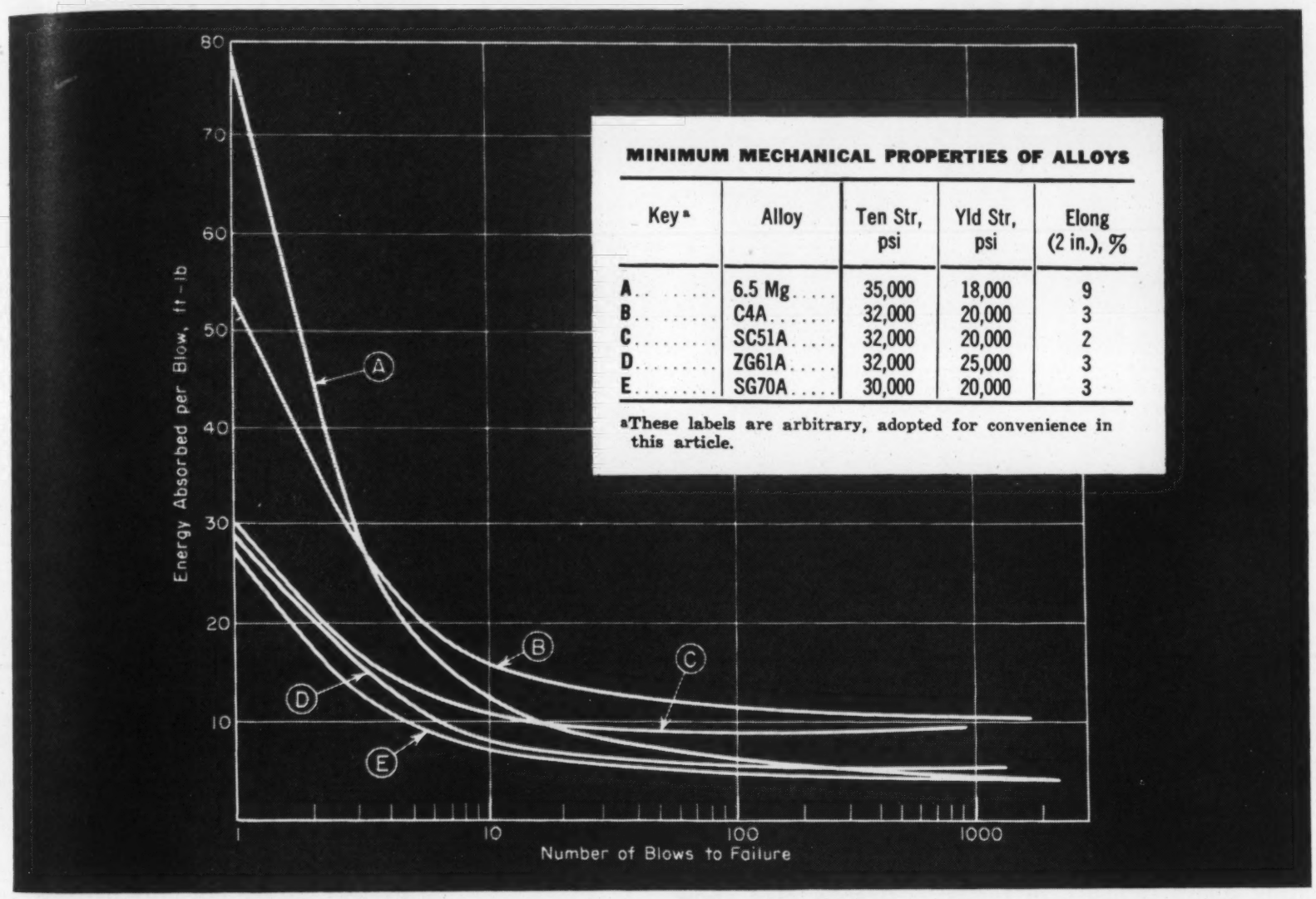
Masland Duraleather Co.
Naugatuck Chemical Div. of U. S. Rubber Co.
O'Sullivan Rubber Corp.
Precision Welder and Flexopress Co.

Aluminum Sand Castings—

How Well Do They Resist | Repeated Impact Fatigue at High Temperatures

by W. J. Reichenecker and D. K. Fox,
Materials Engineering Dept., Westinghouse Electric Corp.



MINIMUM MECHANICAL PROPERTIES OF ALLOYS

Key[a]	Alloy	Ten Str, psi	Yld Str, psi	Elong (2 in.), %
A	6.5 Mg	35,000	18,000	9
B	C4A	32,000	20,000	3
C	SC51A	32,000	20,000	2
D	ZG61A	32,000	25,000	3
E	SG70A	30,000	20,000	3

[a]These labels are arbitrary, adopted for convenience in this article.

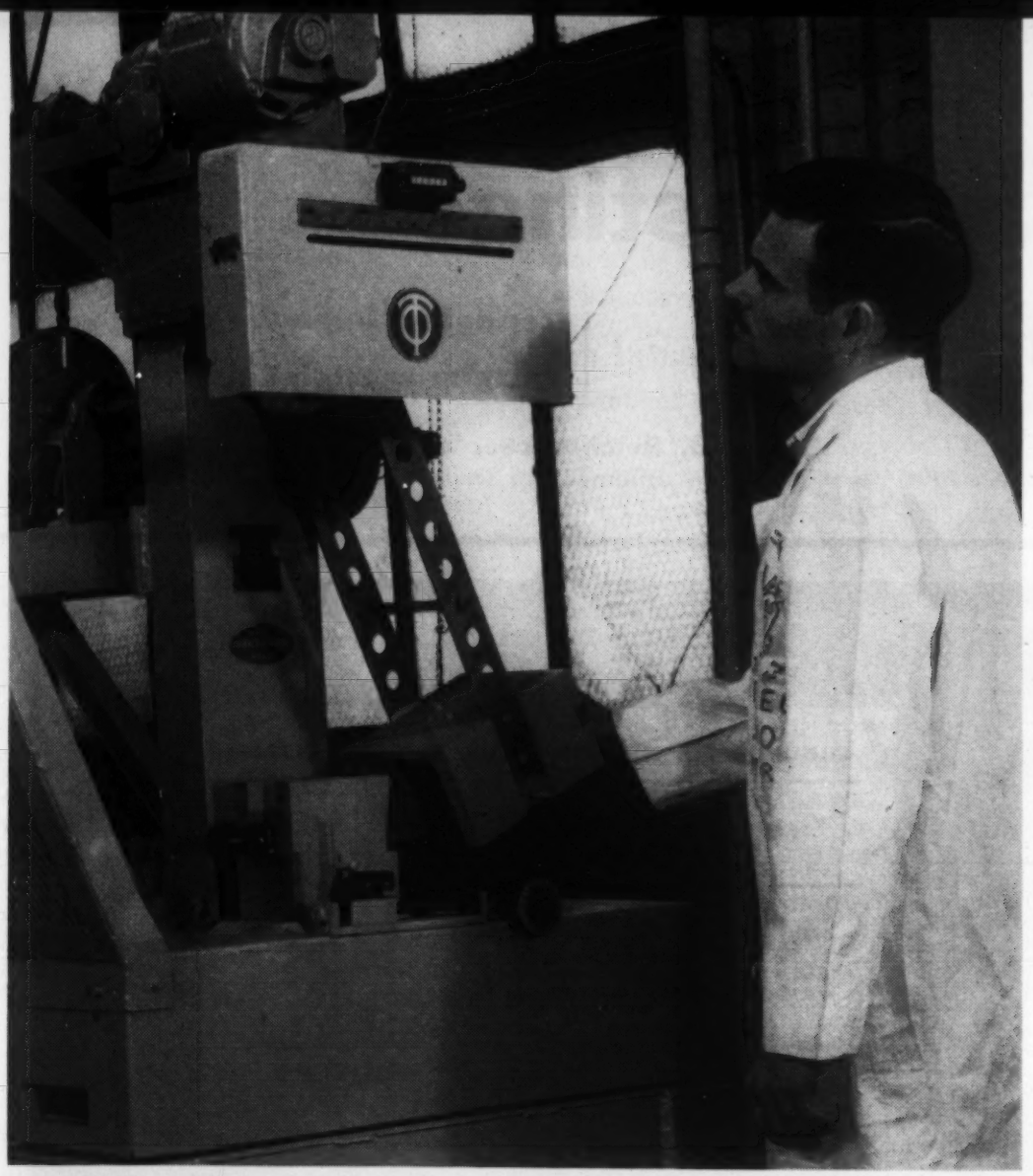
1. Repeated Impact ↑ *This graph compares five alloys.*

The above graph shows how five principal aluminum sand casting alloys react to repeated tensile impact. To date, little data have been published on the impact resistance of these materials. However, this type of information is especially important in many designs where impact forces result from rotating or reciprocating motion.

Alloy ratings differ at high and low energy levels

Note especially that the alloys with the highest single-blow impact strength do not necessarily have the best resistance to repeated impact. The graph shows that the best single-blow tensile impact strength is provided by alloy A, which requires roughly 75-80 ft-lb to produce failure. Alloy B is next in order of single-blow impact strength, requiring roughly 50-55 ft-lb to produce failure. The remaining alloys are grouped in a range of about 25 to 30 ft-lb to produce failure in a single blow.

As energy per blow decreases, the number of blows required to produce failure increases. Despite the lower single-blow impact resistance of the B and C alloys compared to the A alloy, these two alloys have higher impact resistance than alloy A at the lower energy levels. Not indicated is the fact that one alloy C specimen was subjected to 3210 blows at an energy level of 5 ft-lb without producing failure. As with other impact and fatigue data, the values given are useful for comparative purposes only



***Repeated impact** testing machine. Device is similar to conventional pendulum type impact testing machine except that motor drive, magnetic clutch and limit switches permit tests to be conducted at frequency of 10 to 15 blows per min.*

and cannot be used for exact design calculations.

The degree of plastic deformation produced by impact at low energy levels has also been determined. Data show that some degree of deformation is produced in most alloys even at low impact levels. Alloy C (ASTM SC51A) shows the greatest resistance to deformation; in contrast to the others, this alloy shows no deformation at energy levels below 10 ft-lb. Because of its combination of resistance to impact and plastic deformation, alloy C appears to be best suited for use under impact conditions.

Ductility seems to correlate with short-time test

Measurements of elongation at failure show that the ductility of the alloys as measured in tensile impact tests compares favorably with the ductility as measured in short-time tests. No attempt has been made to determine if the frequency of impact has an effect on the behavior of the materials. It is possible that more time between blows would produce somewhat different results.

The graphs show **2. Fatigue at High Temperatures**

The six graphs on the next page show how six aluminum sand casting alloys compare in resisting fatigue at high temperatures. This type of information is particularly useful in designing for high temperature applications involving alternating stresses.

Graphs also show effect of stress level

Each graph shows the fatigue properties of an alloy at 300 and 480 F, as well as at room temperature. The S-N (stress vs number of cycles) curves not only indicate the effects of high temperatures, but also show the effect of stress levels on the endurance limits of

COMPOSITION OF ALLOYS

Alloy[a]	ASTM No.[b]	Composition, %[c]
A		6.5 Mg
B	C4A	4.5 Cu-1.5 Si
C	SC51A	5.0 Si-1.25 Cu-0.5 Mg
D	ZG61A	5.6 Zn-0.6 Mg-0.5 Cr-0.2 Ti
E	SG70A	7.0 Si-0.3 Mg
F	G10A	10.0 Mg

[a]These labels are arbitrary, adopted for convenience in this article.
[b]All alloys denoted by ASTM B26-56T except alloy A.
[c]Balance aluminum.

How Fatigue Was Measured

All fatigue tests were conducted with Sonntag SF-2 constant force machines in which the alternating load is produced by a mechanical oscillator applied to one end of the specimen. For high temperature testing, a furnace was lowered over the sample and supporting frame. The frequency of vibration used was about 18,000 cpm at a load of about 45 lb, including a 20-lb preload.

Although most published fatigue data have been obtained with R. R. Moore rotating beam equipment, the Sonntag flexural fatigue machines are particularly adaptable to high temperature testing. A comparison of tests conducted at room temperature with the two different types of machines showed no significant difference in results.

the materials.

Stress level data is important, as it is not always necessary to design for extended years of service. Since the room temperature endurance limits for cast aluminum alloys are often based on 10^8 cycles or 5×10^8 cycles of reversed stress, the designer may not realize the allowable increase in applied stress if a life of 10^6, 10^7 or shorter span is permissible.

Four main conclusions

On the basis of the information in the graphs several important conclusions can be drawn:

1. Except for alloy F (ASTM G10A), fatigue life or endurance limit is negligibly affected by temperatures from room temperature to 300 F.

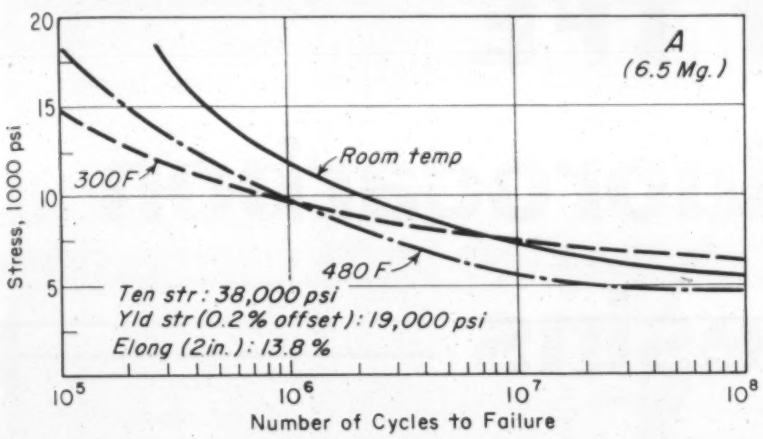
2. Fatigue strength of all of these alloys is noticeably lower at 480 F than at room temperature or 300 F.

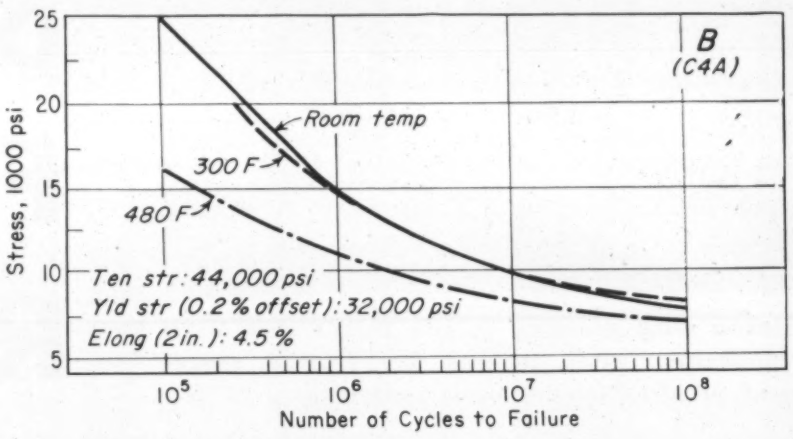
3. When a short life span is permissible, the alloys can be used at somewhat higher stress levels than that indicated by usually published endurance limits based on 10^8 or 5×10^8 cycles of reversed stress.

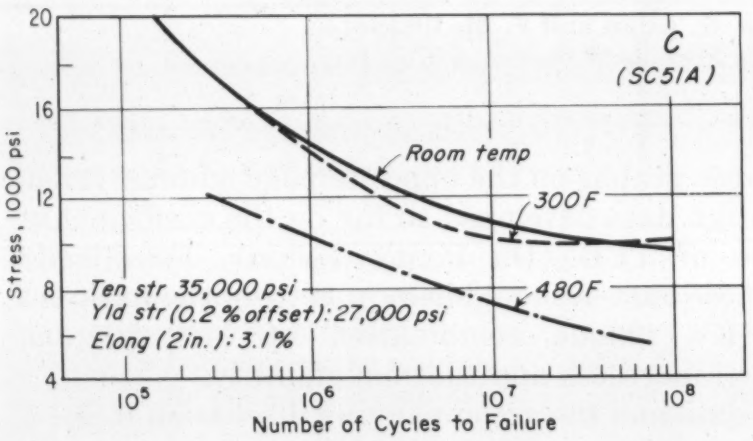
4. When compared at the same temperature, the fatigue characteristics of the six aluminum alloys tested are generally quite similar. Consequently, one alloy cannot be selected in preference to another on the basis of fatigue strength alone. Other properties may be important in any given application and should be considered along with fatigue strength.

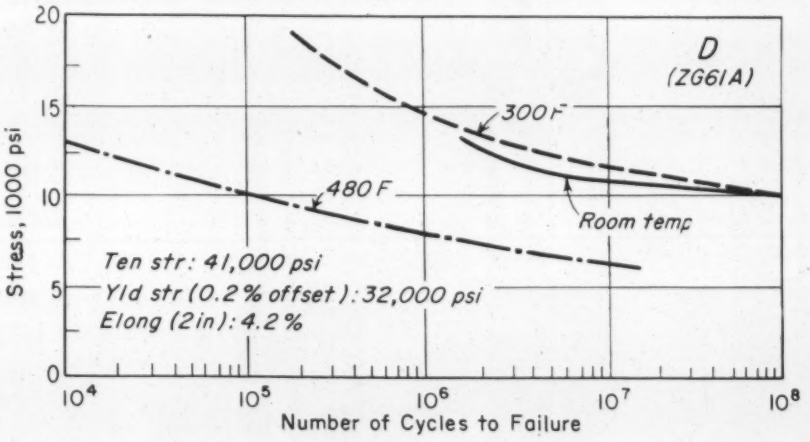
Expect lower values

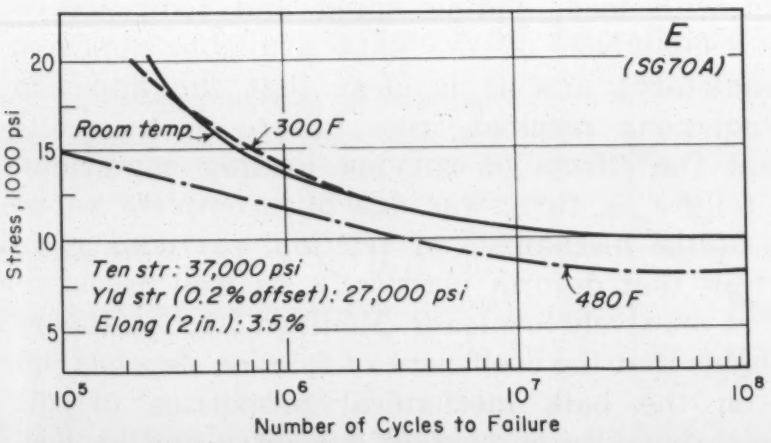
Note that these data are based on test specimens machined from separately cast bars. Somewhat lower results will be obtained on specimens cut from actual castings, since the properties of such castings are affected by section thickness, differences in pouring temperature and other foundry variables.

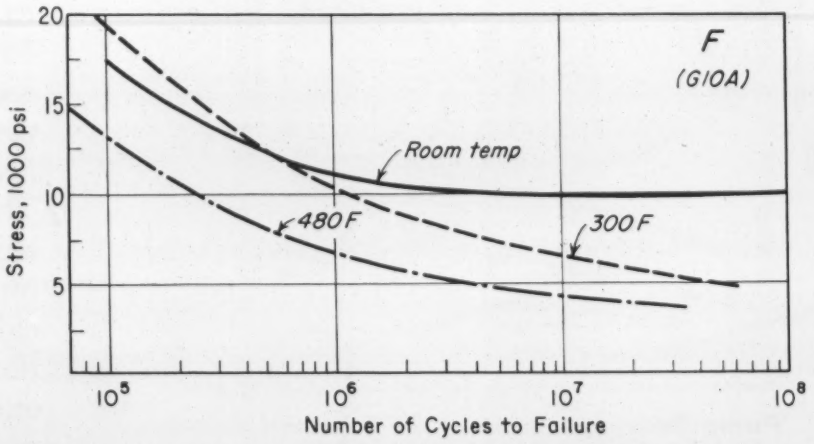




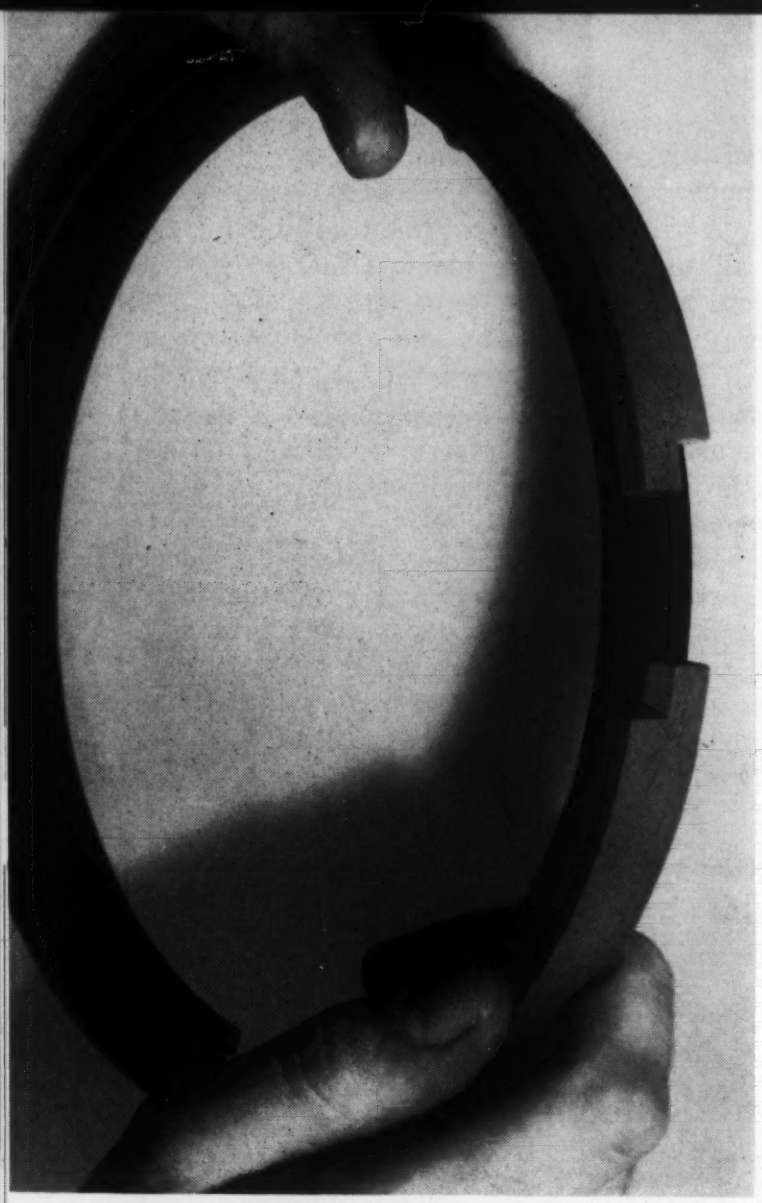




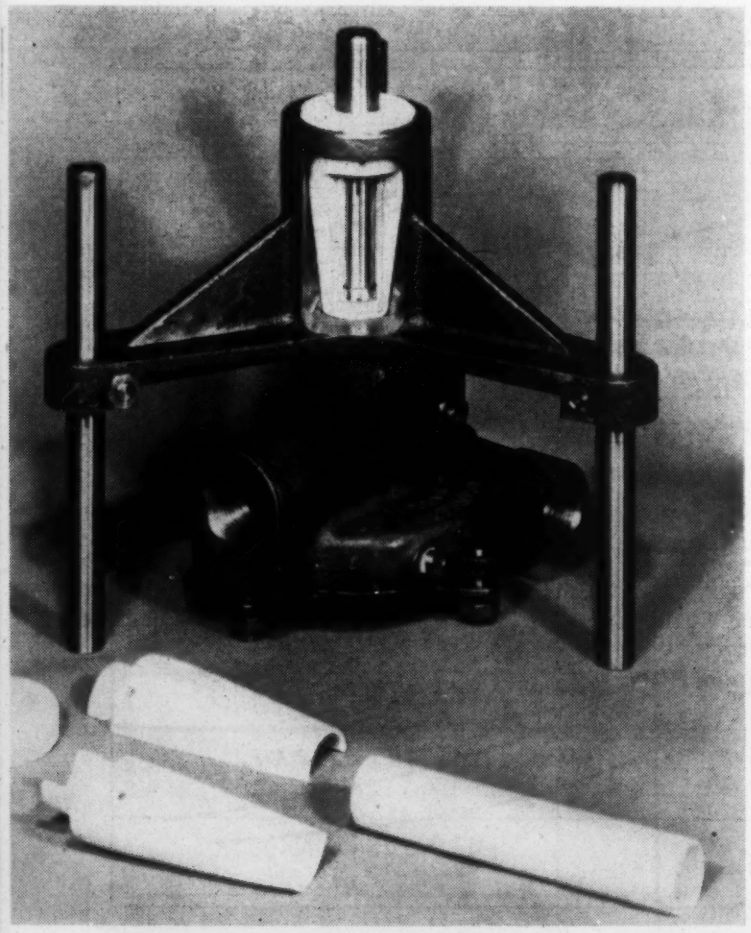




Comparative fatigue properties *of six aluminums and casting alloys at room temperature, 300 F and 480 F.*



Piston ring *designed in two pieces with TFE fluorocarbon resin insures low friction movement in afterburner nozzle control of J-71 jet.*



Pump bearings *made of TFE permit submersion in chemicals. No lubrication is required, precluding contamination of fluid being pumped.*

Here are the . . .

Frictional Properties of TFE Fluorocarbon Resins

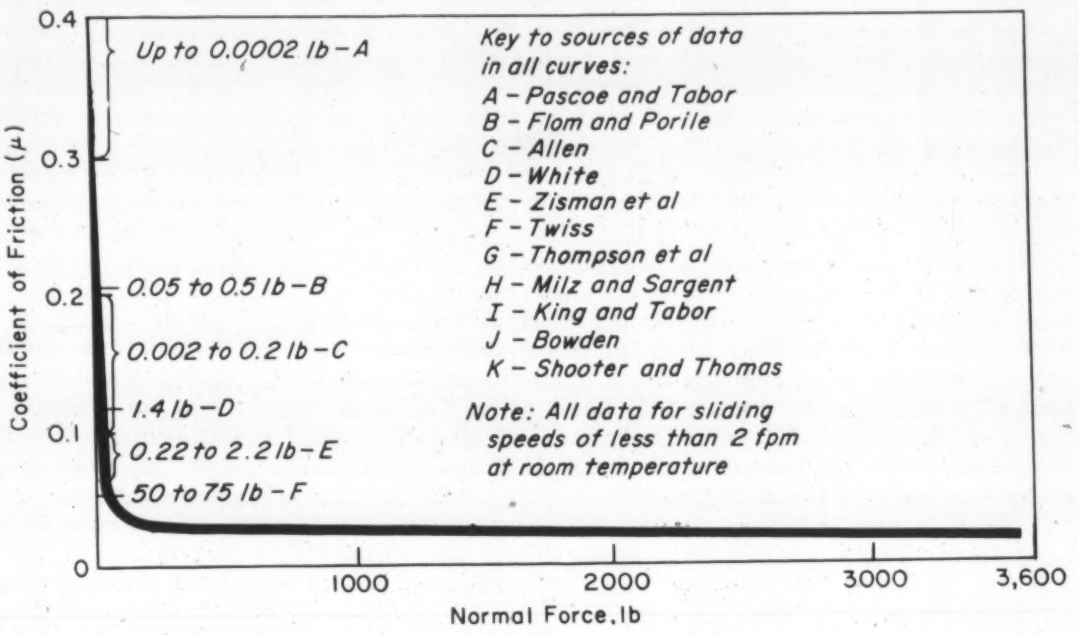
by A. J. G. Allan and F. M. Chapman, *Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc.*

The three graphs on the opposite page summarize all the design data developed so far on the coefficient of friction of TFE (Du Pont's Teflon). Familiarity with these curves should help in getting the most out of TFE's unique combination of low friction, chemical inertness and thermal stability.

The data and the accompanying discussion make it clear that TFE's coefficient of friction varies significantly with load, sliding speed and temperature. Previously, much of the data available appeared contradictory; now it is clear that the apparent contradictions resulted from failure to take into account the effects of varying loading conditions. This failure, in turn, was due to incomplete knowledge of the mechanism of friction, particularly in materials that deform plastically, as well as elastically, at relatively low loads. Modified friction theory now holds that the coefficient of friction depends not only on the bulk mechanical properties of the material, but also on surface geometry and on load and other sliding conditions.

Effect of load

At sliding speeds of less than 2 fpm, TFE's frictional coefficient varies by a factor of 50 over the load range of 2 x 10^{-9} to 2 x 10^{3} lb. The coefficient decreases rapidly as load increases to the 5 to 50-lb range. As load increases above this range the coefficient continues to decrease more gradually. The continual decrease in coefficient with increasing load indicates that TFE bearing surfaces will not seize even under extremely high loads. This has been verified by studies which show that the material cannot be friction welded even when interface temperatures rise well above the material's decomposition temperature.

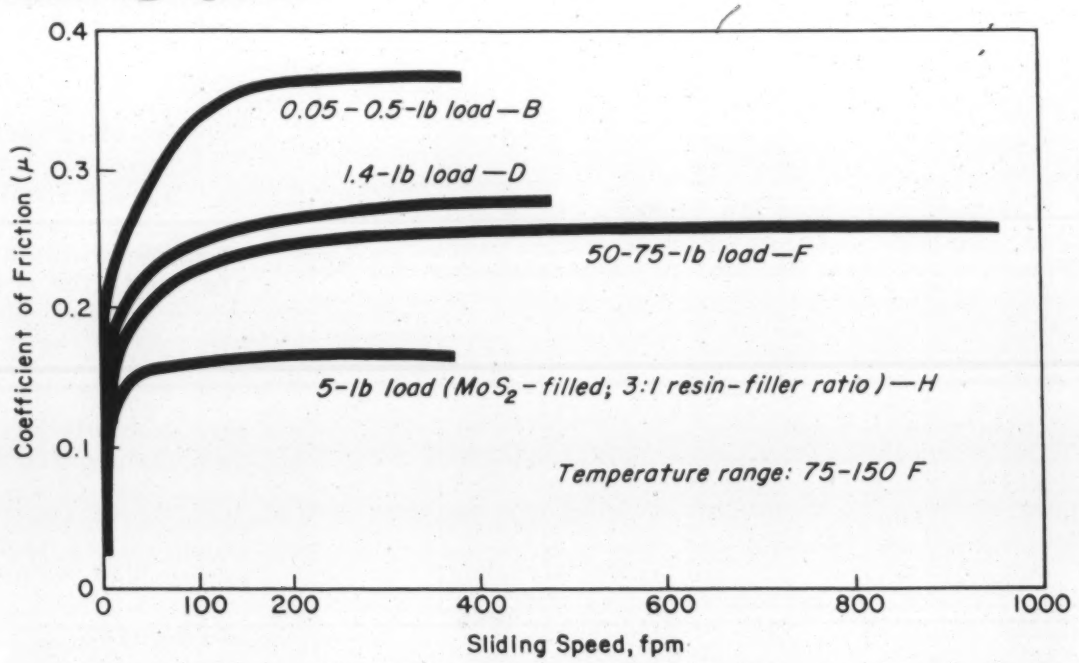

Coefficient of Friction (μ)
0.4
0.3
0.2
0.1
0
Up to 0.0002 lb – A
0.05 to 0.5 lb – B
0.002 to 0.2 lb – C
1.4 lb – D
0.22 to 2.2 lb – E
50 to 75 lb – F
Key to sources of data in all curves:
A – Pascoe and Tabor
B – Flom and Porile
C – Allen
D – White
E – Zisman et al
F – Twiss
G – Thompson et al
H – Milz and Sargent
I – King and Tabor
J – Bowden
K – Shooter and Thomas
Note: All data for sliding speeds of less than 2 fpm at room temperature
1000
2000
3000
3,600
Normal Force, lb

Effect of sliding speed

The greatest benefits of TFE in bearing applications are obtained at loadings higher than 5 lb and at slow sliding speeds. Coefficient of friction increases rapidly with sliding speed up to about 100 fpm under all load conditions, with higher loads producing lower coefficients. This increase in coefficient with increasing speed reduces stick-slip tendencies. Above about 150 fpm, sliding speed has relatively little effect on the coefficient unless speed is so high that interfacial temperatures exceed the crystalline melting point.

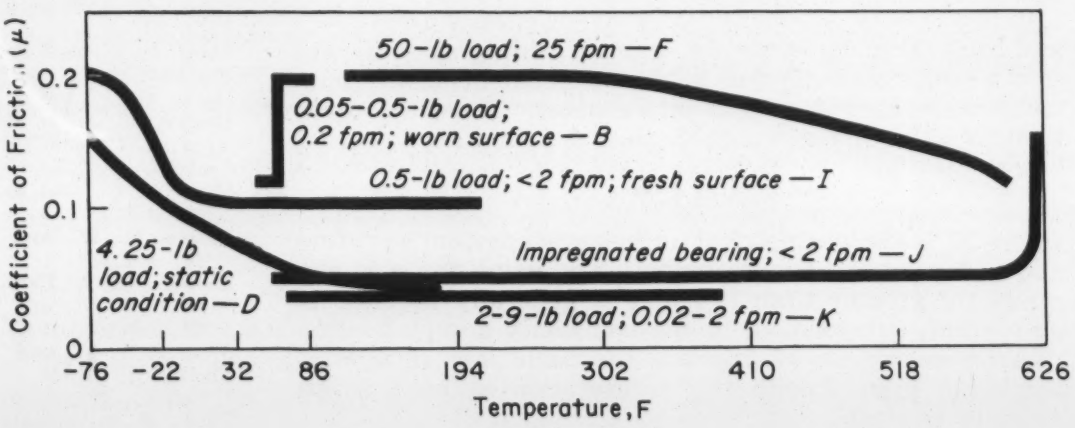
Note that the molybdenum disulfide-filled TFE composition shown here under a 5-lb load exhibits a lower coefficient than would be expected of pure TFE material under the same conditions. This phenomenon can probably be attributed to an increase in hardness of the material, as well as the plate-like structure of molybdenum disulfide. The same benefits have been obtained with other filled TFE compositions.

Reports also indicate that fresh surfaces sliding at 2 to 16 fpm have a coefficient only one-third to one-half the coefficients of surfaces that have been worn at high speeds.



Effect of temperature

Coefficient of friction at slow sliding speeds is relatively constant over the temperature range of 80 to 620 F. The curves also indicate the lower coefficient produced by fresh surfaces as opposed to worn surfaces. The abrupt drop in the coefficient of worn surfaces at low sliding speeds when temperature is dropped from 65 to 61 F coincides with a chemical transition within the polymer structure.



For the theory that explains these results, see next page →

How TFE Data Fit Friction Theory

The data on the preceding pages show the error in the common tendency to assign one coefficient of friction value to a plastics material regardless of load. The plastoelastic nature of the deformation that takes place in stressed plastics makes the frictional coefficient quite dependent on load, particularly at low load levels. Current theory clearly shows qualitatively the nature of this dependence.

Nearly all solid surfaces are rough when viewed on a molecular scale. When two surfaces are placed together, they come into intimate molecular contact only at the high spots, or asperities. Load on the specimens causes these asperities to be crushed down until the softer of the pair of materials can support the load (W). The load is then carried by the interfacial areas of the touching asperities (A), which are only a small fraction of the geometric area of the surface.

Under sliding contact, these areas change and new ones form. The force required to do this is the force of friction (F) and depends on the specific shear strength of the junctions (s) and their area (A):

$$F = As$$

If the deformation of the asperities is plastic rather than elastic in nature, the pressure that the asperities can withstand without further deformation is a constant (p_m) for any given material and is comparable to indentation hardness. Thus, for materials that deform plastically under such conditions, the area of real contact (A) is derived as follows:

$$A = \frac{W}{p_m}$$

The widely accepted law of coefficient of friction holds that frictional force is directly proportional to load. Substituting from the two previous equations for the values of F and W in the accepted equation for coefficient of friction, the equation becomes:

$$\mu = \frac{F}{W} = \frac{As}{Ap_m} = \frac{s}{p_m}$$

Thus, when the area of true contact is exactly proportional to the load, i.e., deformation of the material is purely plastic, the coefficient of friction is constant and independent of load.

Since plastics deform both elastically and plastically the value for real contact area (A) under conditions of elastic deformation must be determined. The theory of elastic deformation of a single spherical asperity pressed against an ideally flat plate, states that area of true contact is related to the load by:

$$A = KW^{2/3}$$

where K is a constant depending on the radius of curvature of the asperity and the elastic constants of the materials in contact. From this equation it would seem that the standard equation for coefficient of friction ($\mu = F/W$) would not be obeyed when deformation is primarily elastic, since substituting $W^{2/3}$ in the standard equation would alter the ratio of frictional force (F) and load (W). However, in common sliding systems, not just a single asperity but a large number of small (nonspherical) asperities come into contact. Thus, the equation for area of real contact when deformation is elastic becomes:

$$A = K'W^n$$

where K' is the geometrical and elastic constant as before and n depends on the geometry. The value for n is significantly greater than 2/3 and is generally so close to unity that, substituting in the commonly accepted equation for coefficient of friction, the basic law of friction is obeyed even though the deformation at each single asperity is elastic.

However, the value of n, though close to, is not exactly unity, and diverges (decreasing in value with decreasing load) from unity at very low loads. Thus, the precise coefficient of friction of sliding surfaces deforming elastically is not constant irrespective of load, but is dependent on the geometry of the surfaces and sliding conditions, as well as the bulk mechanical properties of the materials. As would be expected, the coefficient generally decreases with increasing load, the effect being most noticeable at very low loads.

Plastics vs metals

In general, frictional properties of plastics differ from those of metals in that plastics have lower shear strengths, lower indentation hardness, no oxide film and lower thermal conductivity, promoting higher interfacial temperatures.

In the case of metals, deformation during sliding contact is either plastic (as in the case of an unlubricated metal sphere under initial sliding conditions against a flat surface) or elastic (as in the case of mating and run-in surfaces). In the case of most plastics, deformation is plastoelastic, i.e., a combination of plastic and elastic. Under initial loading, deformation is primarily elastic, but at relatively low loads deformation becomes primarily plastic, accounting for the initial sharp decrease in coefficient with increasing load, and the relatively abrupt leveling off of the curve at a certain load level.

Frictional properties of TFE

Differences in frictional properties of most plastics can be explained generally in terms of their shear strength and hardness, and frictional coefficients can be predicted within a factor of two by calculating the ratio s/p_m, with the observed friction generally being higher. Oddly enough, observed frictional coefficients of TFE are two or three times *lower* than anticipated by this calculation.

Current theory suggests this discrepancy is caused by the inherently low cohesive forces between adjacent polymer chains. The large fluorine atoms effectively screen the large carbon-fluorine dipole, reducing molecular cohesion so that shear force at the interface is low. Shear strength of the bulk material is higher because of interlocking molecular chains.

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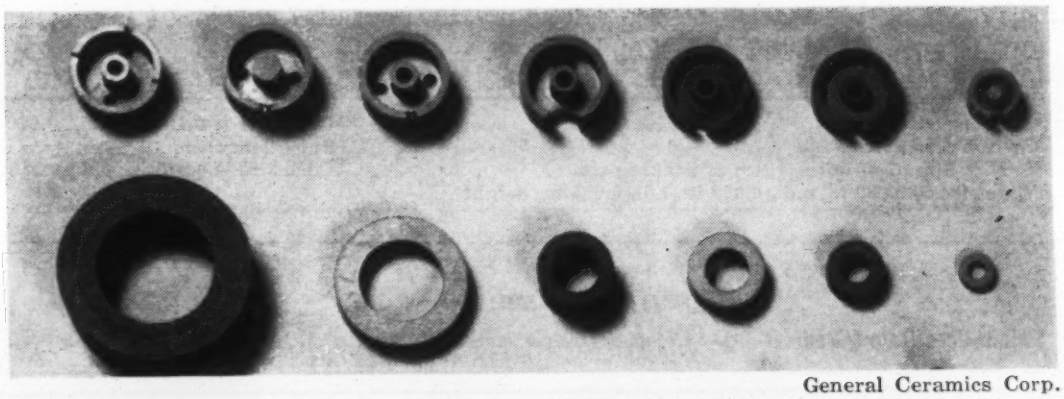
A Guide to

Ferromagnetic Ceramics

PART 2: | *Square loop ferrites*
Microwave ferrites
Permanent magnet ceramics

by George Economos, *Massachusetts Institute of Technology*

■ These ferromagnetic materials are probably less common than the soft ferrites discussed last month. The accompanying tables indicate the properties of typical bodies of each type commercially available from various suppliers.



General Ceramics Corp.

Ferrite cores *are used in a variety of shapes and sizes.*

Square loop ferrites

Square loop or switching ferrites have two stable states of magnetization, resulting in a square or rectangular hysteresis loop. The shape of the entire loop is important in designing with these materials. Such ferrites are used in magnetic computer memory devices, switching devices and magnetic amplifiers. Magnetic computer memory devices are the most advanced application for the materials.

The tables in the accompanying box list properties of proprietary grades of square loop ferrites supplied by various manufacturers. The properties are organized to present those most important for different applications.

Memory devices — The three most important characteristics of a square loop ferrite for memory devices are: squareness ratio of the hysteresis loop, switching time, and "noise," i.e., voltage generated by the half pulses at the peaking voltage of the full pulse.

As a series of pulses of varying amplitude is applied to a square loop ferrite toroid, varying values for B_m and B_r are produced, resulting in a series of loops of different shapes, as shown in Fig 1. Memory devices use sets of pulses of half amplitude, and for proper operation require a high ratio of $B_{-H/2}$: B_H, called squareness ratio, R_s. Thus the value of B at an applied field of half amplitude (–H/2) in the direction opposite

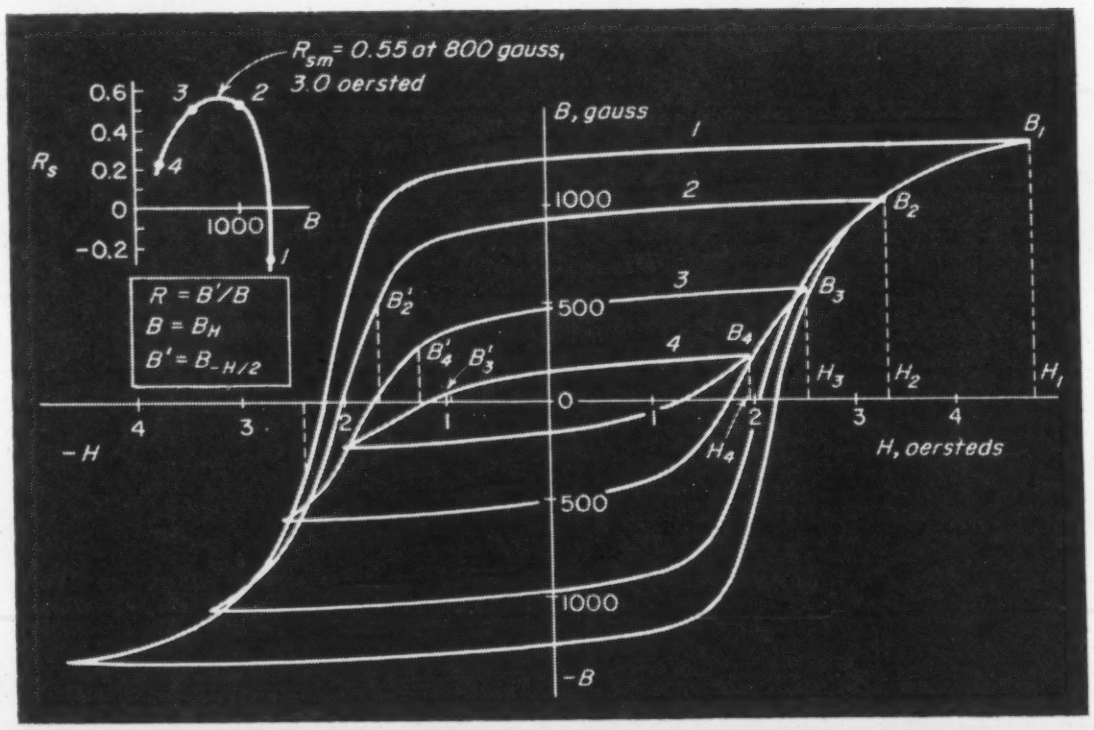


Fig 1*—Squareness ratio measurement from hysteresis loops. Loops 1 to 4 are caused by application of fields of varying amplitudes. Curve at left shows plotting of squareness ratio (R_s) against maximum flux density (B_m) for the four curves, thus deriving maximum squareness ratio (R_{sm}), and indicating field required to utilize highest loop rectangularity.* (Economos)

Properties of Commercial

INTERNATIONAL TELEMETER CORP.

Hysteresis Loop Data

Grade ↓	B_s, g	B_r, g	H_c, oe	B_r/B_s	H_{sm}, oe	τ_{sw}, μsec
T1[a]	1800	1680	1.2	0.94	1.85	1.2
T5-A[a]	2100	1900	0.72	0.96	0.9	5
T5-B[b]	2200	1950	0.37	0.95	—	5

Memory Core Pulse Data

Grade ↓	Drive Pulse			Output Pulse			
	Height, amp-turn	Width, μsec	Rise Time, μsec	τ_{sw}, μsec	τ_{peak}, μsec	I, mv	S/N[c]
80T1[d]	0.820	1.5	0.2	1.3	0.6	>125	>50
80T5-A[d]	0.365	10.0	0.6	4	2.0	> 25	>50
100T1[e]	1.05	1.5	0.2	1.3	0.6	>150	>50

Switch Core Pulse Data

Grade ↓	NI, amp-turn	B_m, g
180T1[f]	1	455
	2	1670
	3	1975
	4	2080
180T5[f]	1	1445
	2	1595
	3	1670
	4	1750
375T5[g]	1	435
	2	1655
	3	1875
	4	1960

[a]Memory core grade.
[b]Switch core grade.
[c]S/N = Signal-to-noise ratio at peaking time.
[d]Core size = 0.080 in. o.d., 0.050 in. i.d., 0.025 in. height
[e]Core size = 0.100 in. o.d., 0.070 in. i.d., 0.030 in. height.
[f]Pulse length is 10 μsec; core size is 0.180 in. o.d., 0.090 in. i.d., 0.090 in. thick.
[g]Core size is 0.375 in. o.d., 0.260 in. i.d., 0.125 in. thick.

MULLARD, LTD. (Ferroxcube)

Switch Core Data (Grade D-1[a])

H_m, oe	B_m, g	H_c, oe	B_r/B_m	R_{sm}	τ_{sw}, μsec
1.4	1700	0.9	>0.9	>0.8	<2.0
2.8	2100	1.2	>0.9	—	<1.0

Memory Core Data (Grade D-2[b])

NI, amp-turn	1 Position, mv	0 Position, mv	τ_{sw}, μsec	τ_p[c], μsec
0.70	>100	<12	1.4	0.60
1.08	>130	<15	1.4	0.60

[a]Core sizes available in D-1 grade, in.:

	FX 1724	*FX 1396*	*FX 1639*	*FX 1638*
O.D.	0.200	0.315	0.527	1.024
I.D.	0.120	0.236	0.343	0.800
Height	0.040	0.080	0.220	0.284

[b]Core sizes available in D-2 grade, in.:

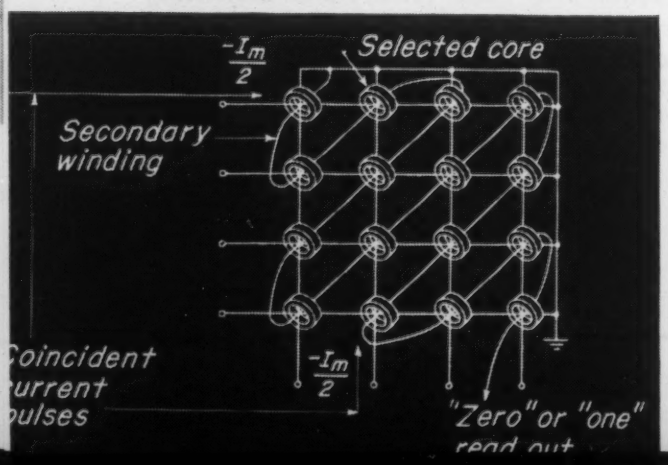
	FX 1508	*FX 1634*
O.D.	0.080	0.120
I.D.	0.050	0.080
Height	0.025	0.025

[c]Average values.

Glossary of Symbols[a]

B—Flux density or induction.
B_d—Flux density at $(BH)_m$.
B_m—Maximum flux density.[b]
B_r—Remanent flux density.
B_s—Saturation flux density.[b]
B_u—Usable flux density, i.e., density at which the 240 F initial permeability is half the 77 F value.
$(BH)_m$—Maximum energy product.
ϵ'/ϵ_o—Equals k' and is the relative dielectric constant commonly encountered in dielectrics (i.e., the ratio of permittivity of the material to that of free space).
g—gauss.
H—Magnetizing force or drive.
H_c—Coercive force.
H_d—Magnetizing force at $(BH)_m$.
H_m—Maximum magnetizing force.
H_{sm}—Magnetizing force for optimum squareness ratio.

Fig 2—*Wiring schematic of a magnetic memory.*



to that required to attain B_m is critical. If the loop is highly rectangular, the half pulses will not disturb the loop shape, nor excite any appreciable voltage in the sensing element (the secondary winding). Plotting R_s versus B_m (or H_m) as shown in Fig 1 will indicate the maximum squareness ratio (R_{sm}) and thus the optimum field required to utilize the highest loop rectangularity.

In a so-called memory device array, such as that shown schematically in Fig 2, the application of a half-amplitude pulse to

Square Loop Ferrites

H_c, oe	B_r/B_m	V_o, v/turn	τ_{sw}, μsec
0.95	0.73	0.3	>1.6
1.40	0.97	2.0	1.0
1.56	0.95	3.0	0.5
1.65	0.94	6.0	<0.4
0.62	0.95	0.7	2.5
0.73	0.93	1.9	0.8
0.75	0.91	3.3	0.6
0.76	0.89	—	0.4
0.38	0.82	0.3	>8
0.62	0.96	0.8	3.5
0.70	0.97	1.8	1.7
0.74	0.96	2.5	1.1

k′—See ϵ'/ϵ_o.
μ_i—Initial permeability.
μ_{max}—Maximum permeability.
NI—Ampere-turns.
oe—oersted.
Q—A quality rating applied to coil or resonant circuits; determined by formula:

$$Q = \frac{\text{Frequency x inductance}}{\text{Resistance}} \times 2\pi$$

R_{sm}—Optimum squareness ratio.
ρ—Resistivity.
ρ_{dc}—Resistivity, measured statically.
T_c—Curie temperature.
τ_{sw}—Switching time.
V_o—Output voltage on switching.

[a] Although many of these terms are not standardized, the ones shown here are used in this article.
[b] Saturation flux density is the theoretically highest flux density value, i.e., when H is at a value where the core material has no effect; maximum flux density is the maximum density for any specified level of magnetizing force.

GENERAL CERAMICS CORP.[a]

Hysteresis Loop Characteristics

Grade ↓	μ_i, g/oe	μ_{max}, g/oe	B_s, g	B_r, g	H_c, oe	B_r/B_s	R_{sm}	H_{sm}, oe	τ_{sw}, milisec
S-1.....	40	515	1780	1590	1.5	0.90	0.8	2.0	1
S-3.....	45	1800	2000	1920	0.65	0.96	0.95	0.80	>4

Memory Core Pulse Data

Grade ↓	NI, amp-turn	'One'(and 1_d) Position, mv/turn	'Zero'$_d$ Position[b], v/turn	τ_{sw}, milisec
S-1[c].....	0.5.....	30	0.016	1.7
	0.7.....	65	0.016	1.4
	0.9.....	140	0.028	1.0
S-3[d].....	0.25....	—	3.5	5.7
	0.35....	23	3.5	4.5
	0.45....	42	3.5	2.8

Switch Core Pulse Data[e]

Grade ↓	H_m, oe	V_o, v/turn	τ_{sw}, milisec
S-1.....	1.2.....	1.5	1.5
	1.6.....	3.5	1.3
	2.0.....	5.5	1.0
	2.4.....	7.5	0.8
S-3.....	1.2.....	1.3	1.9
	1.6.....	2.9	1.6
	2.0.....	4.4	1.2
	2.4.....	5.9	0.9

[a]Core sizes, in.:

	Small	*Medium*	*Large*
O.D.	0.080	0.230	0.375
I.D.	0.050	0.120	0.187
Height	0.025	0.060	0.125

[b]Subscript "d" denotes a disturb pulse (nonswitching pulse).
[c]Pulse length is >1.5 times switching time with 0.2 milisec rise time. 0_d at 1_d peak is <0.005 volt per turn between 0.65 and 0.95 amp-turn.
[d]0_d at 1_d peak is <1 volt per turn over this range.
[e]Data taken from large size cores.

NATIONAL CASH REGISTER CO. (Type N 400-800 Memory Core[a])

Switching Response (for a single turn)

NI, amp-turn	τ_{sw}, μsec	τ_{peak}, μsec	1 Position, mv	0_d Position, mv
0.35.....	3.6	2.0	300	3
0.40.....	3.0	1.8	480	3
0.45.....	2.2	1.5	660	4

Optimum Operating Behavior

Drive Pulse			Output Pulse				
Height, amp-turn	Width, μsec	Rise Time, μsec	τ_{sm}, μsec	τ_{peak}, μsec	1 Position, mv	0_d Position, mv	S/N[b]
0.400	>7.0	0.5	3	2	>25	<7.5	>100

[a]Core size: 0.080 in. o.d., 0.050 in. i.d., 0.025 in. height.
[b]Signal-to-noise ratio at peak.

each of the two magnetizing (or driving) windings causes the toroid to switch if it is in the proper remanant state, i.e., either at B_r or $-B_r$, often called the "zero" and "one" states respectively in coincident memory applications. This switching generates in the secondary winding a large voltage by which the computer circuitry can determine the state of the core in that location. Since the complete memory has to be scanned in each step of a computation or other information gathering sequence, the speed at which the toroid responds is critical for efficient operation. Speeds of better than 1 μsec (10^{-6} sec) have been achieved in some materials. The switching time, τ_{sw}, can be decreased by higher driving pulses, but these may be beyond the ability of the computer circuitry.

Square Loop Ferrites (continued)

LIGNES TELEGRAPHIQUE ET TELEPHONIQUE ("Rectalite")

D.C. Characteristics

Grade ↓	μ_i, g/oe	At R_{sm}							
		ρ, ohm-cm	T_c, F	H, oe	B_r/B_m	H_c, oe	B, g	B_r, g	R_{sm}
4001	400	10^3	428	10	0.90	0.50	4000	3520	—
				2	0.95	0.40	3600	3450	—
4302	100	10^4	500	10	0.92	0.7	3340	3080	—
				0.9	0.97	0.6	2380	2300	0.94
4303	90	2×10^4	554	10	0.92	1.6	2800	2580	—
				2	0.94	1.2	2180	2060	0.76
4304	150	2×10^5	482	10	0.92	1.4	2500	2300	—
				1.8	0.94	1.0	1960	1840	0.78
4401	200	2×10^3	536	10	0.92	0.55	3660	3360	—
				2	0.97	0.55	3360	3260	—
4402	130	10^3	545	10	0.92	0.60	3500	3220	—
				2	0.95	0.60	3060	2900	—
4601	84	10^4	716	10	0.94	1.10	3460	3260	—
				1.4	0.95	0.85	2260	2160	0.83
4701	240	10^3	554	10	0.92	1.15	3380	3120	—
				1.6	0.95	1.0	2600	2480	0.83

Switching Response

Grade ↓	H_m, oe	V_o, mv	τ_{sm}, μsec	Grade ↓	H_m, oe	V_o, mv	τ_{sm}, μsec
4001[a]	1.4	630	5.5	4401[b]	1.0	125	4.0
	1.6	730	4.5		1.4	270	2.0
	1.8	850	4.0		1.8	440	1.2
	2.0	950	3.5		2.0	520	1.0
4302[b]	1.10	400	1.5	4402[a]	1.14	110	11
	1.30	400	1.3		1.60	200	8
	1.70	410	0.8		1.95	280	6
	2.10	590	0.8		2.40	360	4.8
4302[a]	1.02	160	4	4601[b]	1.25	95	3.0
	1.7	200	3.2		1.8	240	1.5
	1.04	280	2.8		2	270	1.0
	2.25	310	2.5		2.5	380	0.8
				4601[a]	2.8	190	6.0
4303[b]	2.0	190	2.0	4701[b]	1	70	3.0
	2.2	240	1.8		1.5	140	2.0
	2.4	300	1.5		2	250	1.2
					2.5	350	1.0
4304[b]	1.8	160	2.0	4701[a]	1.16	130	12.0
	2.0	240	1.8		1.63	220	8.0
	2.2	270	1.4		2.10	315	6.0
	2.45	320	1.2		2.45	370	4.5

[a]Toroid size: FN 114 = o.d.—0.0965 in.; i.d.—0.0560 in.; height—0.0508-0.0763 in.
[b]Toroid size: FN 112 = 0.d.—0.0508 in.; i.d.—0.0318 in.; height 0.0304 in.

As important as the squareness ratio and the switching time is the voltage generated by the half pulses at the peak voltage of the full pulse. This factor is measured by the signal-to-noise ratio shown in Fig 3; a high ratio is desirable.

Magnetic switches — The primary requirements for magnetic switches are a high remanence, a high $B_r:B_m$ ratio, and a low coercive force. Although the speed of switching can be important depending on the application, the circuitry and the size of the toroid can be varied to permit the use of higher driving pulses to attain rapid switching.

Other uses for square loop ferrites, such as magnetic amplifiers, have not as yet found widespread application. The potential of these relatively new materials would seem to offer many interesting future applications.

Microwave ferrites

Data on microwave ferrites are quite limited because 1) they are one of the most recently developed ferrite materials, and 2) only a few companies offer these materials for sale (many companies are producing only for their own consumption). The limited data shown in Table 1 indicate the scarcity of information available. With materials that are so new and in a field where the basic concepts are still quite elusive, the design engineer should contact producing companies for more details and cooperation.

The properties of prime importance in microwave ferrites are the Faraday rotation effect and the ferromagnetic resonance absorption. The Faraday effect is the resulting rotation of a microwave beam when it passes through the magnetized material as shown by the accompanying schematic drawing (Fig 4). The degree of rotation is dependent on the chemical and structural composition of the material, its thickness, and the strength of the applied magnetic field. The unique feature of the Faraday effect in microwave ferrites is that the rotation of the reflected beam is in the same direction as that of the original beam. This phenomenon permits use of the materials as gyrators, isolators, circulators and phase shifters.

The resonance absorption in the microwave range is a limiting factor in the use of microwave ferrites because of the magnetic losses associated with such absorption. A typical absorption peak is shown in Fig 5. Resonance absorption line width (ΔH, in oer-

steds) at the peak half-height should be as narrow as possible.

Ceramic permanent magnets

Ceramic materials used for permanent magnets are not ferrites, but are closely related to them. They are derivatives of the natural mineral magnetoplumbite ($PbFe_{12}O_{19}$). In commercial compositions barium is usually substituted for the lead because of the processing difficulties inherent in lead-containing ceramics. Strontium can also be accommodated in the hexagonal lattice, but it is relatively expensive.

The most desirable property of permanent magnet materials is a high energy product (BH) on the demagnetizing cycle of the hysteresis loop. Thus, the materials must be capable of achieving high remanence or high coercivity, or better yet, high values for both. A highly rectangular loop is also advantageous.

Two major types of ceramic

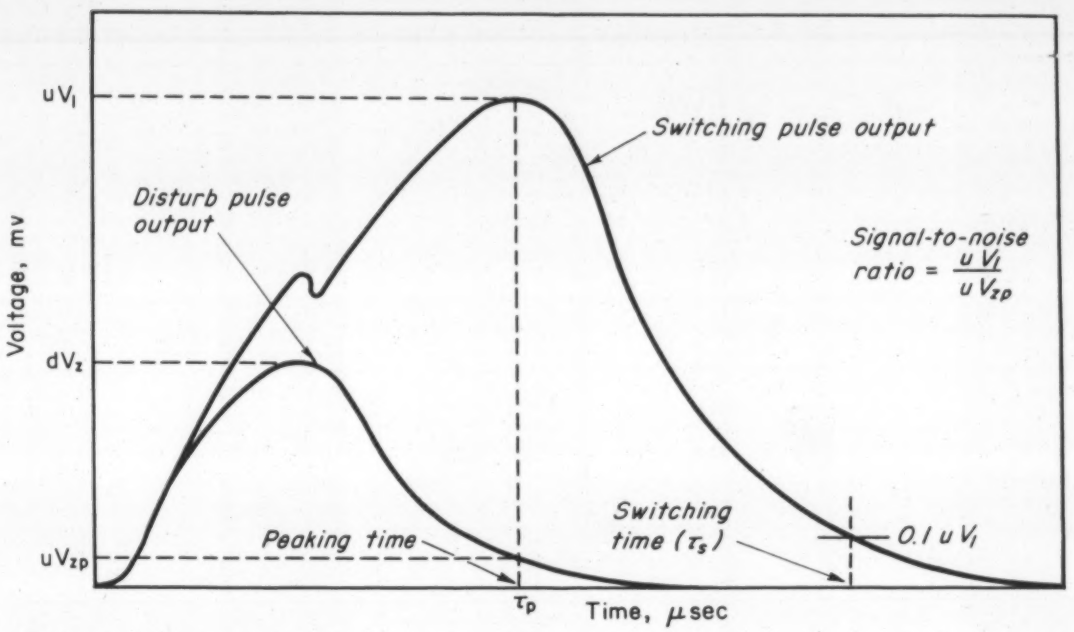


***Fig 3**—Typical switching and disturb output signal, from which is obtained signal-noise ratio.*

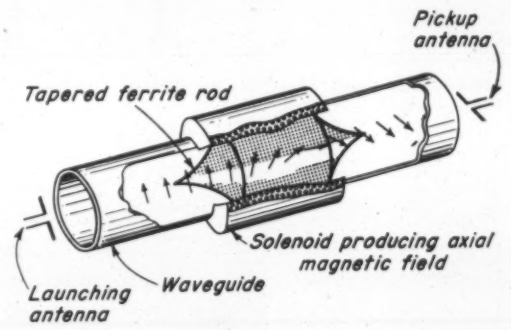


***Fig 4**—Faraday rotation of a microwave beam by a ferrite.* (von Hippel, A. R., *Dielectrics and Waves*, J. Wiley & Sons, Inc., 1954)

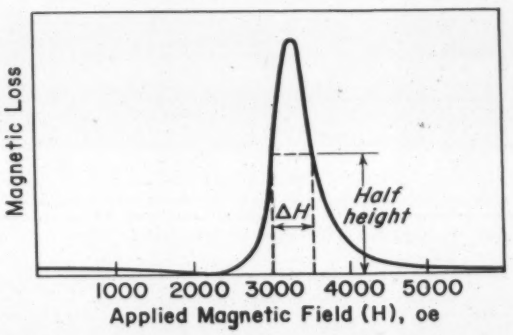


***Fig 5**—Resonance absorption by a microwave ferrite.* (Kingerey)

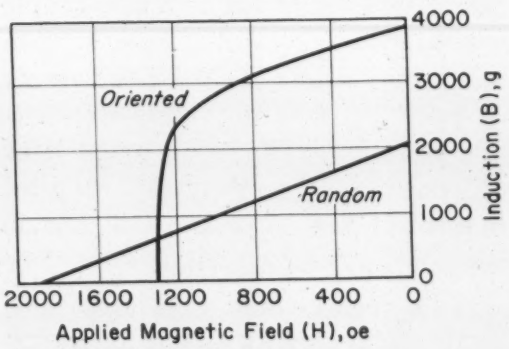


***Fig 6**—Demagnetizing curves of isotropic (random) and anisotropic (oriented) magnetobarite permanent magnets.* (Kingerey)

TABLE 1—CHARACTERISTICS OF COMMERCIAL MICROWAVE FERRITES

Raytheon Mfg. Co. Grade ➡	R-141	R-151	R-161	R-191
Loss/Inch (10 kmc), db	—	0.04	—	—
ϵ'/ϵ_o (10 kmc)	3.8	—	13	10.5
B_s, g	230	2300	3300	3000
Rotation (10 kmc), deg/in.[a]	—	115	—	—
Tan δ[e] (10 kmc)	0.0007	0.0005	0.007	0.003
Line Width ($\triangle$ H), oe	800	400	500	200
T_c, F	536	572	1094	1094
Front/Back Ratio	>10	—	High	>20
Uses	L-Band isolators	X-Band gyrators; high power at X-band, low power at C-band; S-band and above for isolators	S-Band and above for isolators	Down to L-band for isolators

Mullard Ltd. "Ferroxcube" Grade ➡	B3	B4	B5	Trans-Tech, Inc. Grade ➡	TT-390	TT-414
Applied Magnetic Field, oe	7500±250	3500	1700±50	Loss/Inch, db	0.025	0.02
Frequency Range, kmc	34.2-35.5	9.3[b]	9.375[b]	ϵ'/ϵ_o (9375 mc)	13	11.5
Input, VSWR	>0.85	0.9	0.86	B_s, g	1900	600
Insertion Loss, db				Rotation (9.375 kmc), deg/in.[c]	180	—
Forward	0.5	0.6	0.7	Phase Shift (3 kmc), deg/in.[d]	—	7
Reverse	>12	16	21	T_c, F	608	212
Uses	Q-Band medium power isolator	X-Band high power isolator	X-and low power isolator	Uses	X- and K-band as rotation device; S through K-band as isolators	S-Band and lower as phase shifter and rotation devices

[a]0.2 in. dia rod in 5/8 in. i.d. guide at 300 oe.
[b]Center.
[c]0.25 in. dia rod in 15/16 in. i.d. guide at 300 oe.
[d]0.25 in. x 0.75 in. bar in 1½ x 3 in. o.d. guide at 500 oe.
[e]Tan δ-dissipation factor.

TABLE 2—CHARACTERISTICS OF PERMANENT MAGNET FERRITES

Type[a] ↓	BH_{max}, 10^{-6} g/oe	B_r, gauss	H_c, oersted	B_d,[b] gauss	H_d,[b] oersted	H_{sat}, 10^{-3} oersted	ρ, ohm-cm	Temp Coef of BH_{max}, %/°F	T_c, F	Comments
Indox I	0.95	2100	1700	1055	900	10	10^6	0.105	860	—
" V	3.5	3800	2000	1920	1820	10	—	0.105	860	—
Ferrimag I	1.0	2100	1650[c]	1130	885	—	10^6	0.083	—	Isotropic
" V	3.5	3900	2000	—	—	—	—	—	—	Oriented
Ferbalite 5802	1.4	2600	1700	1500	930	—	10^6	—	—	—
" 5803	0.6	1800	1500	900	650	—	10^6	—	—	—
" 5804	0.9	2100	1600	1100	800	—	10^6	—	—	—
Fercolite 5201	1.5	2400	1800	1400	1100	—	100	—	—	Cobalt ferrite
" 5202	1.3	2500	1250	1300	1000	—	5×10^5	—	—	Compositions useful up to 140 F
" 5203	1.2	2600	1000	1850	650	—	100	—	—	—
Magnadur 1	0.95	2000	1750	950	1000	14	10^6	—	—	Isotropic
" 2	2.5	3600	1400	2200	1135	14	10^6	—	—	Oriented
" 3	2.25	3000	1900	1600	1400	14	10^6	—	—	Oriented
Cromag	0.8	2000	1550	950	850	—	10^6	—	752	—
Ceramagnet A	1.01	2200	1700	1150	865	—	—	0.086	—	—
F-300	0.84	2000	1600	—	—	—	10^6	0.088	842	—

[a]Indox—Indiana Steel Products Co. Magnadur—Mullard Ltd. F-300—D. M. Steward Mfg. Co.
Ferrimag—Crucible Steel Co. of America. Cromag—Henry L. Crowley & Co., Inc.
Ferbalite and Fercolite—Lignes Telegraphiques et Telephoniques. Ceramagnet A—Stackpole Carbon Co.
[b]At (BH) max. [c]Intrinsic coersive force (H_{ci}) = 2900 oe.

permanent magnets are produced: isotropic (random) and anisotropic (oriented). Typical demagnetizing curves for both types are shown in Fig. 6.

The isotropic type is made by standard ceramic techniques, producing a homogeneous random dispersion; the major constituent likely to be present is crystallites of magnetobarite ($BaFe_{12}O_{19}$). Materials with energy products of over one million gauss-oersteds are available; stability is provided by high coercivity values.

The anisotropic type is made by orienting the magnetic crystallites before pressing in the die cavity. Subsequent sintering causes the crystallites to grow in a given plane, yielding a pseudo-single crystal effect, i.e., a highly rectangular loop. Energy products of over 3½ million gauss-oersteds are available. Typical properties of commercial permanent magnet materials are shown in Table 2.

What's next in ferrites?

Magnetostriction exploited — Transducer design is currently almost entirely dependent on barium titanate-base materials. The magnetostrictive properties of the ferrites offer great promise for this type of application. Coupling coefficients (a measure of the efficiency with which a material converts energy from one form to another) of over 30% have been reported for some compositions. Also, the wide Curie temperature ranges offered by the ferrites promise to relax substantially the service temperature limitations currently imposed on transducers.

Microwave limitations lifted— The limitations of ferrites in the microwave region have been well established. New hexagonal materials which seem to be a sort of hybrid combination of magnetoplumbite and cubic ferrites (trademarked Ferroxplana) promise to lift these present limitations.

High resistivity, narrow resonance absorption line width—The magnetic garnets ($Re_3Fe_5O_{12}$), primarily those containing rare earth cations (Re), have high resistivity and narrow resonance absorption line widths. Present data, though limited, are promising.

Single crystals wanted—Single crystals of all the materials—even the most complex combinations—would offer endless opportunities in design. When crystal growing techniques are developed to the point where uniformity and perfection are accurately controlled, the ultimate in materials will be available to the engineer and designer.

Acknowledgment

The author would like to thank the various cooperating companies for assistance in compiling the properties of the various materials published here, and personnel of the Allen-Bradley Co. for helpful suggestions on the method of presentation.

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16 AWARDS

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You need not write up your entry in the form of an article. Entries will not be judged for literary quality. See back page of this folder for details on the information that must be submitted with each entry.

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b. A description of requirements in service and/or fabrication that must be met by the product and the material.

c. A description of the previously used materials (if entry is a redesign).

d. A description of the material or materials selected for the product entry.

e. An explanation of why the material or materials were selected for the product. Describe the advantages or benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

In general, entries should show that the materials selected for the product —

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- Lower basic materials cost
- Less material required
- Improved appearance
- Permitted a new design
- Reduced production costs
- Improved service performance
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- Reduced or eliminated maintenance
- Permitted lower cost design
- Allowed greater design flexibility
- Simplified production and fabrication

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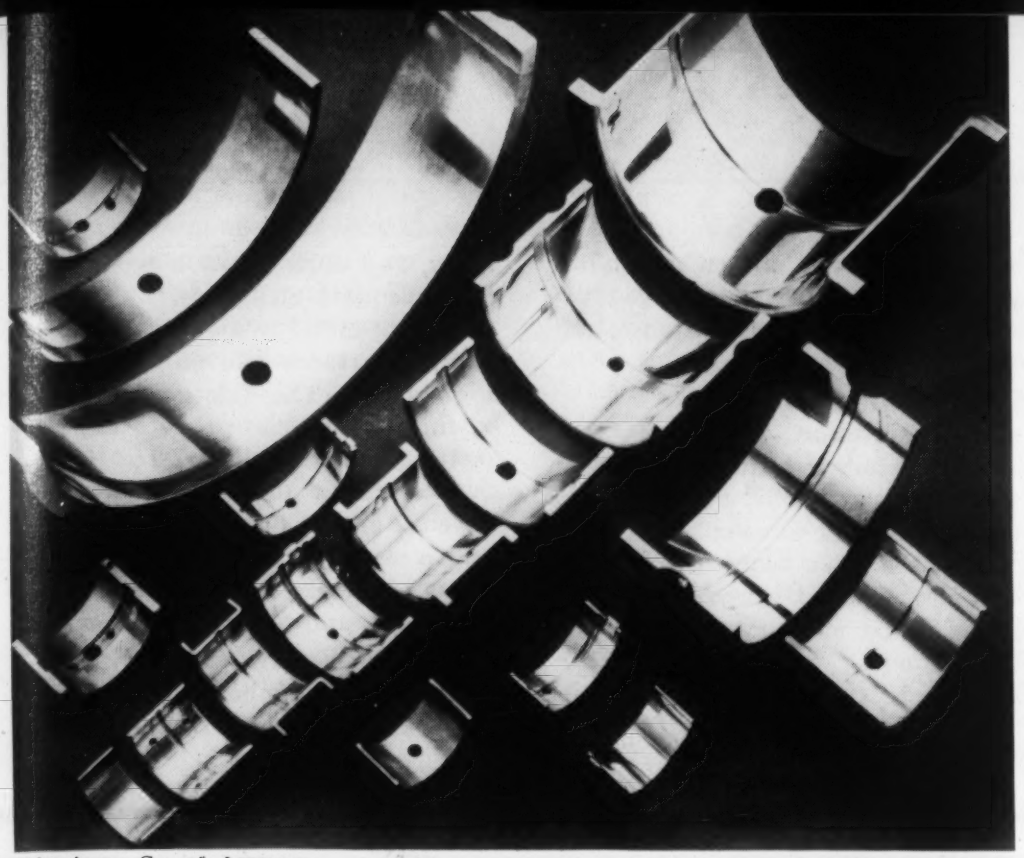
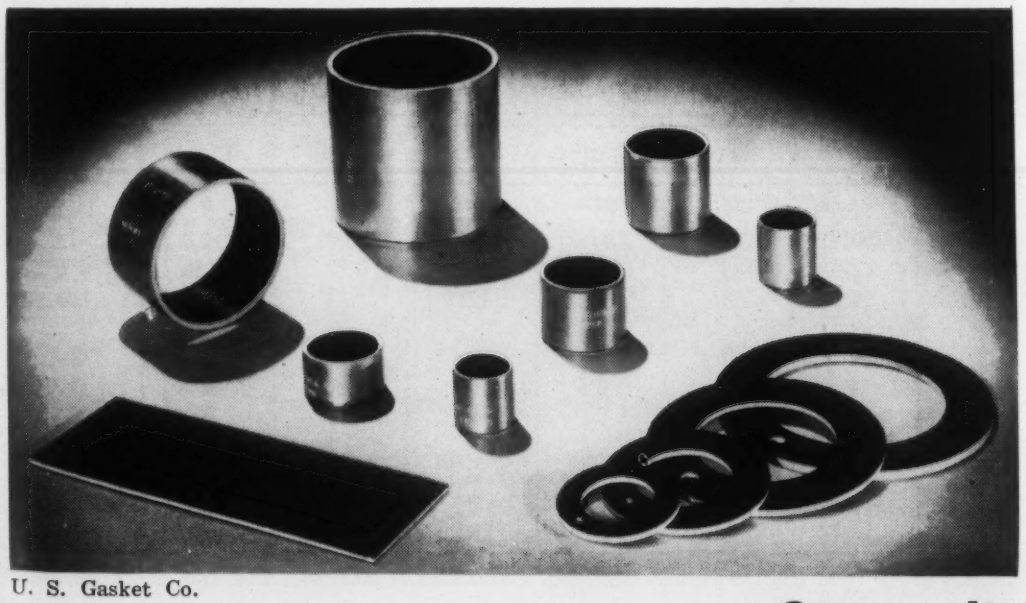


Aluminum Co. of America

Metallic

E. I. du Pont de Nemours & Co.

Nonmetallic



U. S. Gasket Co.

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Materials
in Design Engineering

Manual No. 153
October 1958

Selecting Sleeve Bearing Materials

by Richard Booser,
Motor and Generator Div.,
General Electric Co.

The success or failure of a bearing is largely determined by the materials of which it is made. Many bearing materials are available, each having special properties that recommend it for particular applications. This manual covers:

- *Factors you should consider in selecting bearing materials.*
- *The significant engineering properties of the principal bearing materials.*

Selection factors

The properties of bearing materials differ widely. For this reason the designer must analyze operating conditions carefully to determine which properties are likely to be most important in a particular application. Such an analysis may show that just one or two properties are essential (e.g., load capacity or fatigue resistance); then again it may show that a considerable number of properties will be important. In general, the most important operating properties of a bearing material are its: 1) compatibility and wear resistance, 2) embeddability and conformability, 3) fatigue resistance, 4) corrosion resistance, and 5) load capacity.

Compatibility and wear resistance

Satisfactory compatibility between the bearing and shaft during metal-to-metal contact is usually the most critical operating requirement. Even in well-lubricated bearings there is bound to be metal-to-metal contact upon starting until an oil film is generated. Contact can also occur in misaligned bearings, at high spots, and during run-in when there is inadequate clearance.

During metal-to-metal contact, the sliding surfaces rub on microscopic high spots. The friction developed at these points can produce localized melting and welding. The subsequent seizing damage that occurs depends on the mechanical, chemical and metallurgical properties of the materials, and on the nature of any lubricants and additives present.

A comprehensive summary of the compatibility of bearing materials is given in "Selecting Bearing Metals

TABLE 1—PERFORMANCE CHARACTERISTICS OF COMMON BEARING ALLOYS

Material →	Tin-Base Babbitt	Lead-Base Babbitt	Cadmium	Copper-Lead	Lead Bronze	Tin Bronze	Aluminum Alloy	Silver Plate	Babbitt-Surfaced 3-Component Bearing
Bearing Brinell Hardness									
Room Temp	20-30	15-25	30-40	20-30	40-80	60-80	45-50	25	—
300 F	6-12	6-12	15	20-23	40-60	60-70	40-45	25	—
Shaft Brinell Hardness (min)	150 or less	150 or less	200-250	300	300	300-400	300	300	230 or less
Load Carrying Capacity, psi	800-1500	800-1200	1500-2000	1500-2500	3000-4500	4000+	4000+	4000+	2000-4000+
Max Operating Temp, F	300	300	500	350	450-500	500+	225-300	500	225-300
Compatibility[a]	1	1	1	2	3	4	5	2	1
Conformability and Embeddability[a]	1	1	2	2	4	5	3	3	2
Corrosion Resistance[a]	1	3	5	5	4	2	1	1	2
Fatigue Strength[a]	5	5	4	3	2	1	2	1	3

[a]Arbitrary scale ranging from 1 (best) to 5 (poorest).

Compatibility of Bearing Materials

TABLE 3—COMPATIBILITY OF COMMON NONMETALLIC

Material →	Oil-Impregnated Maple	Phenolic Laminate[b]	Graphite-Filled Phenolic Laminate		Filled Phenolic (60% molybdenum disulfide)		Nylon	
			No Oil	Oiled[b]	No Oil	Oiled[b]	No Oil	Oiled[b]
Dwell Period, min to start of wear	125	22	2	16	12	15	9	1125
Wear Rate, in./hr	0.0005	0.017	0.0005	0.0004	0.0008	0.001	>1.0	>1.0
Coef of Friction During Wear	0.12	0.22	0.17	0.13	0.08	0.12	0.86	0.82
Max Temperature, F	114	265	137	137	121	129	—	410
Bearing Appearance After Testing[c]								
Mushrooming	0	0	0	0	0	0	9	9
Scoring	1	4	0	0	0	0	0	5
Color	0	—	0	0	0	0	0	0
Shaft Appearance After Testing[c]								
Pickup	0	0	0	0	0	0	0	4
Scoring	0	2	0	0	0	0	0	0
Color	1	—	1	1	0	0	0	2

[a]250 psi load on ¼-in. test pin against 1½-in. shaft at 700 fpm. Shaft is carbon steel with a hardness of Rockwell C25 and a 12μ in. rms finis
[b]Lubricated with one drop of oil.
[c]Arbitrary scale ranging from 0 (no effect) to 10 (extreme damage).

That Will Not Seize," M/DE, June '58. The relative compatibility and other performance characteristics of common bearing alloys are also shown in Tables 1 and 2. Tables 3 and 4 describe the compatibility of various nonmetallic bearing materials.

Table 2 shows that tin and lead babbitts have similar dwell periods before wear begins to occur. The tin babbitt has less tendency to pickup on a shaft than lead babbitt, but has a greater tendency to score the shaft.

These tables also indicate:

1. Aluminum, because of its short dwell period together with its high wear rate, needs a good oil supply.

2. Leaded tin bronze does not cause any shaft scoring.

3. Zinc bronze has an exceptionally low wear rate.

4. Cadmium-nickel has a long dwell period which makes it useful where a limited oil supply is available.

5. Silver plate also has a long dwell period and provides a very low wear rate and negligible shaft damage.

A comparison of both metallic and nonmetallic bearing materials is given in Fig 1. These data indicate that the materials with the best ability to operate under limited lub-

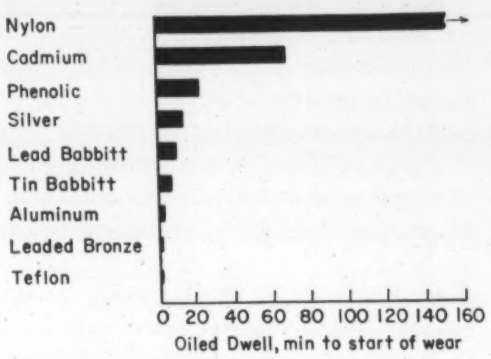


***Fig 1**—Comparative resistance of various bearing materials to wear when initial lubrication is poor. Oiled dwell is measure of time before wear starts to occur after initial application of one drop of oil.*

TABLE 2—COMPATIBILITY OF COMMON BEARING ALLOYS[a]

Material →	Tin Babbitt[b]	Lead Babbitt[c]	Aluminum[d]	Leaded Tin Bronze[e]	Cadmium-Nickel[f]	Silver Plate	Zinc-Bronze[g]
Shaft Material →	AISI C1117[h]	AISI C1117[h]	AISI 4142[i]	AISI B1111[j]	AISI 4140[k]	AISI 4140[k]	AISI 4142[i]
Dwell Period, min to start of wear	7	10	2	0	68	13	6
Wear Rate, in./hr	0.03	0.06	0.26	0.18	0.01	0.003	0.003
Coef of Friction During Wear	0.33	0.31	0.32	0.12	0.32	0.24	0.44
Max Temperature, F	240	295	221	186	232	240	284
Bearing Appearance After Testing[l]							
Mushrooms	4	8	6	4	7	0	2
Scoring	4	5	6	2	7	1	1
Color	6	0	1	0	8	—	5
Shaft Appearance After Testing[l]							
Pickup	0	5	4	5	0	0	0
Scoring	5	3	3	0	5	0	1
Color	5	2	3	0	3	—	6

[a]250 psi load on ¼-in. test pin against 1½-in. shaft at 700 fpm. One drop of 100 SUS oil initial lubrication.
[b]89 tin-7.5 antimony-3.5% copper.
[c]77 lead-13 antimony-10% tin.
[d]91.5 aluminum-0.5 tin-1 copper-1% nickel.
[e]80 copper-10 tin-10% lead.
[f]98.6 cadmium-1.4% nickel.
[g]61 copper-35 zinc-2 manganese-1 silicon-1% lead.
[h]Rockwell A54, 9μ in. rms finish.
[i]Rockwell C25, 11μ in. rms finish.
[j]Rockwell B84, 9μ in. rms finish.
[k]Rockwell C25, 12μ in. rms finish.
[l]Arbitrary scale ranging from 0 (no effect) to 10 (extreme damage).

BEARING MATERIALS[a]

Sintered Nylon		Teflon		Asbestos-Filled Teflon	
No Oil	Oiled[b]	No Oil	Oiled[b]	No Oil	Oiled[b]
2	22	0	0	44	0
1.4	0.32	0.37	0.38	0.0011	0.0007
0.64	0.56	0.17	0.17	0.24	0.17
334	331	—	—	185	157
6	4	9	9	1	1
7	3	—	—	0	0
0	0	—	—	0	0
8	8	0	0	0	0
0	0	0	0	0	0
0	0	0	0	9	9

TABLE 4—COMPATIBILITY OF CARBON-GRAPHITE BEARING MATERIALS[a]

Type →	Grade A	Grade B	Babbitt-Impregnated	Silver-Impregnated	Copper-Impregnated	Bronze-Impregnated
Dwell Period, min to start of wear	37	5	0	50	2	2
Wear Rate, in./hr	0.0007	0.011	0.0004	0.0015	0.0012	0.0044
Coef of Friction During Wear	0.17	0.20	0.20	0.56	0.12	0.32
Max Temperature, F	193	193	162	369	121	245
Bearing Appearance After Testing[b]						
Mushrooms	0	0	0	0	0	0
Scoring	0	6	2	0	1	4
Color	0	0	0	0	0	0
Shaft Appearance After Testing[b]						
Pickup	0	0	1	0	0	2
Scoring	0	3	2	0	0	3
Color	5	3	5	7	3	4

[a]250 psi load on unlubricated ¼-in. test pin against 1½-in. shaft at 700 fpm. Shaft material is AISI 4142 steel with a hardness of Rockwell C25 and a 12μ in. rms finish.
[b]Arbitrary scale ranging from 0 (no effect) to 10 (extreme damage).

rication are nylon, cadmium-nickel, laminated phenolics, silver plate, and the babbitts.

Embeddability and conformability

Embeddability is that property of a bearing material which allows it to absorb foreign particles with a minimum of scoring and wear. Conformability is that property of a bearing which allows it to compensate for misalignment and conform to geometric errors.

Good embeddability and conformability are characteristic of soft metal bearing materials with a low modulus of elasticity. Because of their low moduli of elasticity, the babbitts are unsurpassed for both embeddability and conformability.

The usual combination of good embeddability with good conformability is not necessarily found in nonmetallic bearing materials. Carbon-graphite, for example, has a low modulus of elasticity which permits some conforming of the material to shaft deflections and misalignment. However, because of its high hardness, the material has very poor ability to embed dirt.

Fatigue resistance

The fatigue resistance of bearing materials is important in applications where reciprocating loads, a pounding action, or other alternating stresses are encountered. In such cases, cracks are initiated just below the surface of the material at points of maximum shear stress. In the case of babbitt these cracks propagate at a right angle to the surface down to the bond with the backing material. They then follow along the backing material and join other similar fatigue cracks. When the bearing material is sufficiently weakened it begins to flake loose.

The relative fatigue strength of various bearing alloys is shown in Fig 2. As will be discussed later, the fatigue resistance of babbitts can be considerably improved by using them as a thin overlay on a stronger backing material such as strip steel. The babbitt layer on heavily loaded bearings is frequently reduced to 0.005 in. or less to produce greater fatigue strength. However, this decrease in thickness is accompanied by a loss in embeddability.

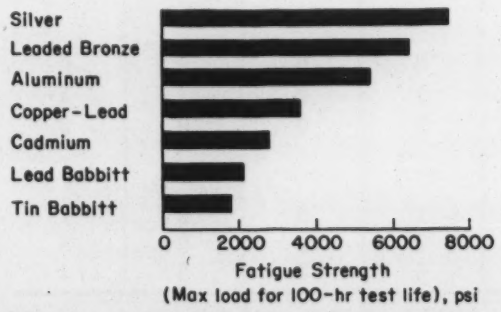


***Fig 2**—Comparative fatigue resistance of bearing metals.*

Corrosion resistance

Corrosion resistance is important where uninhibited industrial lubricating oils are used. If inadequate lubrication schedules are followed, these oils oxidize, and the oxidation products formed can attack and corrode cadmium, lead, zinc and some copper bearing alloys. Attack can be minimized by such modifications as applying a thin flash of indium over cadmium or lead bearing alloys, or by adding tin to lead babbitt. In general, both tin and

TABLE 5—PHYSICAL PROPERTIES OF BEARING MATERIALS

Material ↓	Brinell Hardness	Ten Str, psi	Mod of Elast, 10^6 psi	Density, lb/cu in.	Coef of Exp, 10^{-6} per °F	Ther Cond, Btu/hr/sq ft/°F/ft
METALS						
Lead Babbitt	21	10,000	4.2	0.36	14	14
Tin Babbitt	25	11,000	7.6	0.27	13	32
Copper-Lead	25	8,000	—	—	—	170
Silver	25	23,000	11	0.38	10.9	238
Cadmium	35	—	8	0.31	16.6	53
Aluminum Alloy	45	22,000	10.3	0.10	13.5	119
Leaded Bronze	60	34,000	14	0.32	9.9	27
Tin Bronze	70	45,000	16	0.32	10	29
Steel	150	75,000	30	0.28	6.4	29
Cast Iron	180	35,000	23	0.26	5.7	30
Porous Bronze	40	18,000	—	0.23	10.5	17
Porous Iron	50	25,000	—	0.22	6.7	16
PLASTICS						
Teflon	D60[a]	3,000	0.06	0.08	56	0.14
Nylon	M79[b]	9,300	0.41	0.04	55	0.14
Phenolic	M100[b]	10,000	0.5	0.05	12	0.21
OTHER NONMETALLICS						
Rubber	—	—	—	0.04	43	0.09
Wood	—	900	1.8	0.02	2.7	0.11
Carbon-Graphite	730	2,000	2	0.06	1.5	10
Cemented Tungsten Carbide	1800	—	81	0.51	3.3	40
Fused Aluminum Oxide	2000	—	50	0.14	8.2	1.6

[a]Durometer hardness. [b]Rockwell hardness.

TABLE 6—APPROXIMATE PRICES OF SLEEVE BEARINGS ($)[a]

Bearing Size →	½-In. I.D.	1-In. I.D.	2-In. I.D.	4-In. I.D.
Cast Tin Babbitt, Steel Back	2.25	3.10	4.60	10.25
Cast Lead Babbitt, Steel Back	2.20	2.95	3.90	7.55
Leaded Bronze	0.20	0.43	2.07	12.00
Lead Babbitt, Steel Strip Back	0.06[b]	0.09[b]	0.19[b]	0.96[b]
Tin Babbitt, Steel Strip Back	0.08[b]	0.10[b]	0.21[b]	1.05[b]
Aluminum, Steel Strip Back	0.08[b]	0.10[b]	0.21[b]	1.02[b]
Copper-Lead, Steel Strip Back	0.10[b]	0.12[b]	0.25[b]	1.29[b]
Three-Layer, Steel Strip Back	—	0.16[b]	0.28[b]	1.44[b]
Sintered Bronze	0.08	0.16	1.47	10.85[b]
Sintered Iron	0.06	0.11	1.21	11.60[b]
Nylon Lining	0.16	0.23	—	—
Carbon-Graphite	0.21	0.48	4.05	10.00
Rubber	—	2.36	6.70	21.31

[a]Based on large quantities and bearings with a length-diameter ratio of 1.5.
[b]These bearings are normally supplied with a smaller length diameter ratio than 1.5. However, for purposes of comparison the 1.5 ratio has been used in computing costs.

aluminum alloy bearings are largely unaffected by oxidized oils.

Load capacity

The load capacity of a bearing is closely related to the material's compatibility and mechanical properties, as well as to the design of the bearing, the lubricant used, and the type of load. The load-carrying capacity of various bearing metal alloys is shown in Table 1.

Modulus of elasticity and tensile strength

The modulus of elasticity and tensile strength of a number of bearing materials are given in Table 5. These properties are usually most important in designing the bearing housing and support. In general, lower strength materials such as babbitts require some support and are normally used as a thin layer over a stronger metal such as steel, bronze, or cast iron.

Hardness

The hardness of a bearing material (see Table 5) should be as low as possible, yet still provide the desired strength and wear resistance. Use of the lowest permissible hardness will provide the greatest embeddability and conformability and tend to minimize journal scoring. Where high bearing hardness is required for high loads it is necessary to: 1) be sure that the shaft is harder than the bearing material, 2) have a good quality finish on both the bearing and the shaft, 3) pay more careful attention to alignment, and 4) be sure that surfaces are free from dirt, and 5) be sure that there is an adequate supply of lubricant.

Coefficient of expansion

The coefficient of expansion of a bearing material (see Table 5) must be taken into account in establishing bearing-to-shaft clearances at the expected operating temperatures. If a material has a low coefficient of expansion, then a greater clearance than normal must be allowed at room temperature so that the correct clearance will exist at higher operating temperatures.

Thermal conductivity

The thermal conductivity of a bearing material (Table 5) indicates its ability to dissipate the heat caused by friction. Materials with low conductivity require a good supply of lubricant or some other means of carrying away heat. Cooling water is often used for this purpose, as in the case of phenolic laminates used in roll neck bearings in steel mills.

Temperature limits

It is difficult to establish the maximum temperature limits of bearing materials. Tables 1 and 9 give typical recommendations. If operating conditions and temperatures are likely to be severe, some sort of laboratory or field testing should be conducted to insure that the bearing material will perform satisfactorily.

Cost and availability

Cost and availability are very often the deciding factors in selecting a bearing material. The principal reason for the difference in the cost of lead babbitt and tin babbitt bearings is that lead costs less than tin. Both silver and cadmium have many excellent bearing properties, but their limited availability and high cost limit their use to specialized applications.

However, the high cost of a bearing material need not necessarily keep it from being considered. Frequently a thin layer of the bearing material can supply the desired surface characteristics while a cheaper backing material supplies the necessary structural strength.

Table 6 summarizes the cost of bearings made of various materials.

Practically all engineering metals have been used at one time or another as bearing materials. A good many of these metals have proved unsatisfactory for one reason or another. The most popular metals in use today are: 1) soft babbitt metals, composed primarily of lead and tin, 2) copper alloys, including the lead and tin bronzes and the softer copper-lead alloys, 3) aluminum alloys, 4) silver, 5) porous metals, and 6) cast iron and steel.

Cadmium has been used as a babbitt replacement for heavy loads in the past, but its use has decreased in recent years because of its high cost. Some zinc alloys were used as wartime substitutes for the bronzes, but their use has largely disappeared and they will not be considered. Although they are not primarily bearing materials, iron and steel will be considered briefly since they are frequently used where cost is a major factor and the severity of operation is not too great.

Metal bearing materials

Babbitts

The lead and tin-base babbitts are the best known and most widely used metal bearing materials. They are principally noted for their excellent properties under boundary lubrication or dirty operation, and for their excellent compatibility and conformability.

Compared to other bearing materials, generally the babbitts have lower load-carrying capacity and fatigue strength, and are higher in cost and of more complicated design. Also, as shown in Fig 3, their strength decreases rapidly with increasing temperature. However, these shortcomings can often be avoided by using an intermediate layer of high strength, fatigue resistant material between a steel backing and a thin babbitt surface layer. Such composite bearings frequently eliminate any need for using alternate materials with poorer compatibility characteristics.

Tin and lead babbitt bearings are used in a wide range of applications including small appliances, fractional horsepower motors and internal combustion engines, as well as the largest motors, generators,

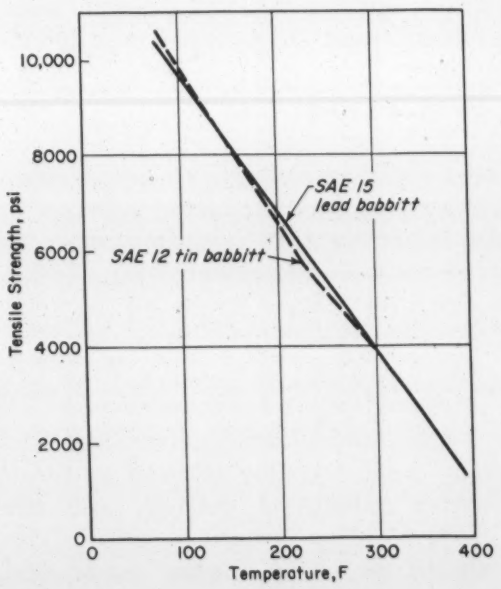


***Fig 3**—Strength of lead and tin babbitt drops rapidly with increasing temperature. However, this deficiency can often be overcome by using a higher strength backing.*

gas turbines, and industrial and marine gear units.

Although the babbitts used in such applications may have a similar composition, there are great variations in the way the materials are applied. In smaller bushings for FHP motors and in reciprocating engine bearings, the babbitt is generally applied as a thin coating over a flat steel strip. After machining of oil-distributing grooves and holes, the strip is cut to size and then rolled and shaped into the finished form. These bearings are generally available for shafts with diameters from 0.5 to 2 in. They are produced in very large quantities and offer an excellent combination of low cost and good bearing properties.

For larger and heavier duty bearings, a thicker layer of babbitt is cast on a rigid backing of steel or cast iron. The babbitt layer is usually ⅛ to ¼ in. thick.

Table 7 shows the specifications established by the SAE for babbitt compositions. Grades 10 to 12 are tin-base babbitts and grades 13 to 15 are lead-base. The ASTM has adopted a similar specification (B23). ASTM grades 1 to 5 are tin-base and 6 to 18 are all lead-base alloys.

Tin babbitt

Tin-base babbitt bearings generally contain 80 to 90% tin alloyed with about 3 to 8% copper and 4 to 14% antimony. In general, an increase in copper or antimony content produces an increase in hardness and tensile strength, and a decrease in ductility. However, an increase in these hardening constituents above the range shown in Table 7 will lead to decreased resistance to cracking and fatigue. Of the tin-base alloys, the ASTM 2 and 3 alloys (similar to SAE 11) are most commonly used for industrial equipment, and the SAE 12 grade is most widely used in automotive applications.

Lead babbitt

The lead babbitts are based upon the lead-antimony-tin alloys and have a structure of hard crystals in a relatively soft matrix similar to the tin-base materials. Composition generally ranges from 10 to 15% antimony and up to 10% tin. The SAE 14 alloy, containing 10% tin, is quite popular for many industrial, railroad and automotive applications. The SAE 13 alloy is used where a softer babbitt is desired, and the SAE 15 alloy is used because of its ability to carry higher loads and provide longer fatigue life.

Compared to tin babbitts, the lead babbitts are less costly, have somewhat better fatigue resistance at low temperatures, and have less tendency to score a shaft. Lead babbitt bearings are used in much greater volume than tin babbitts and have proved superior in a number of critical applications. Nevertheless, tin babbitt is still frequently preferred for industrial applications because of its better corrosion resistance, easier bonding, and lower tendency to segregate.

TABLE 7—COMPOSITION OF SAE BABBITTS (%)[a]

SAE No. ➡	10	11	12	13	14	15
ASTM B23 No. ➡	Alloy 1	—	Alloy 2	—	Alloy 7	Alloy 15
Tin (min)	90	86	88.25	5-7	9.25-10.75	0.9-1.25
Antimony	4-5	6-7.5	7-8	9.05-11	14-16	14-15.5
Lead	0.5	0.5	0.5	Bal	Bal	Bal
Copper	4-5	5-6.5	3-4	0.5	0.5	0.59
Iron	0.08	0.08	0.08	—	—	—
Arsenic	0.1	0.1	0.1	0.25	0.6	0.8-1.2
Bismuth	0.08	0.08	0.08	—	—	—
Zinc	0.005	0.005	0.005	0.005	0.005	0.005
Aluminum	0.005	0.005	0.005	0.005	0.005	0.005
Others (total)	0.2	0.2	0.2	0.2	0.2	0.2

[a]Percentages of minor constituents represent limiting values except where allowable range is noted.

Three-component bearings

These bearings are especially designed to improve the strength and fatigue resistance of the babbitt materials. Generally, they consist of: 1) a low carbon steel backing, 2) an intermediate layer of copper, bronze, silver or aluminum, and 3) an overlay of babbitt ranging from about 0.001 to 0.020 in. thick. The intermediate layer increases the mechanical strength of the babbitt, and also provides reasonably good bearing properties in case the tin babbitt surface layer is destroyed in operation.

Fig 4 shows the marked improvement in fatigue strength produced by using a thin babbitt layer. This thin layer does not have as good embeddability as thick layers. Nevertheless, the high load capacity of three-component bearings has made them extremely popular for heavy duty service in reciprocating engines for automobiles, trucks, diesel equipment and aircraft. The load capacity of such bearings ranges up to 4000 to 5000 psi as compared with a limit of 1500 psi for the babbitt itself.

One type of three-layer bearing is produced by continuously depositing a powder of 60% copper and 40% nickel on a steel strip which is then passed through a sintering furnace. Lead babbitt is then vacuum cast on the porous copper-nickel matrix to impregnate the pores and provide the surface overlay.

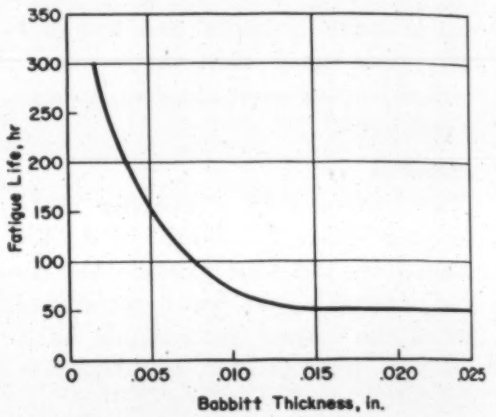


***Fig 4**—Effect of thickness on life of babbitt bearings (2000-psi load).*

Sometimes an intermediate layer of copper-lead, leaded bronze, silver or aluminum is also used under the babbitt. This layer is machine finished, and a thin layer of the babbitt is added by precision casting or plating.

A grid-type bearing is also produced for heavy-duty surfaces; it uses a knurled intermediate layer of copper alloy or silver. The final overlay structure then consists of a grid filled with a lead babbitt.

Copper alloys

Many copper alloys are available for bearing applications. In general, these alloys can be grouped into three classes: 1) copper-lead, 2) leaded bronzes, and 3) tin and high strength bronzes.

The composition and properties of typical copper alloy bearing mate-

TABLE 8—TYPICAL COPPER ALLOY BEARING MATERIALS

Alloy	SAE No.	Nominal Composition, %				Tensile Strength, psi[a]	Brinell Hardness[a]
		Copper	Tin	Lead	Zinc		
Copper Lead	480	65	—	35	—	8,000	25
Leaded Bronze	67	78	6	16	—	28,000	55
Red Brass	40	85	5	5	5	34,000	60
Bearing Bronze	660	83	7	7	3	34,000	60
Leaded Tin Bronze	64	80	10	10	—	36,000	65
Gun Metal	62	88	10	—	2	44,000	70
Aluminum Bronze	68	89	(1 iron, 10 aluminum)			70,000	140

[a]Typical values for sand castings.

rials are shown in Table 8. The compatibility of these alloys decreases as lead content is lowered. However, there is a corresponding increase in load capacity, strength, hardness, wear resistance and fatigue strength as other alloying elements such as tin, aluminum, phosphorus and zinc are added.

Cost of copper alloy bearings varies widely. Simple bronze bushings are cheaper than corresponding babbitt materials, whereas copper-lead bearings are more expensive than their babbitt counterparts. In general, the copper alloys provide greater load capacity, better high temperature operation, and more wear resistance than the softer babbitts. However, the babbitts are superior where a combination of high load and high speed is encountered.

Copper-lead

The simplest copper bearing material is the binary copper-lead mixture which can contain from 20 to 40% lead. Lead is practically insoluble in copper, and a cast copper-lead microstructure consists of a copper matrix containing dispersed lead pockets. These pockets of lead serve as reservoirs for maintaining a continuous lead film on the bearing surface. The tendency for lead to segregate is minimized by careful control of melting and casting. Tin, or up to 5% silver, is sometimes added to minimize segregation.

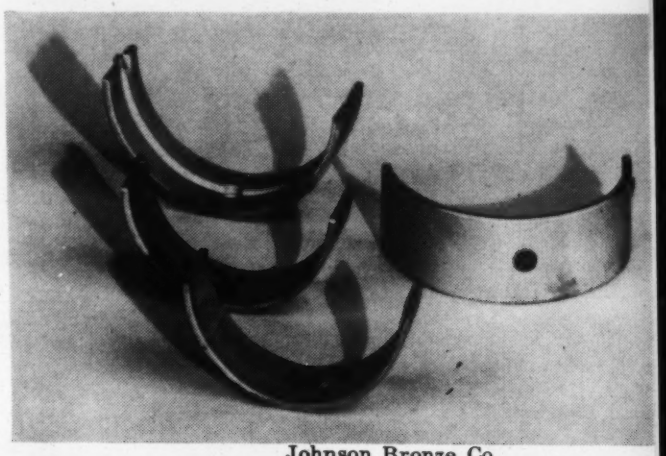
A steel backing is usually used with copper-lead bearings to produce added strength. Hardness of copper-lead bearings is about the same as for babbitt at room temperature, but is higher than for babbitt at temperatures approaching 300 F. A thin babbitt overlay is sometimes applied to copper-lead bearings to promote compatibility and conformability.

Corrosion of both lead and copper in the alloy is a problem, and corrosion resistance is sometimes provided by diffusing a coating of indium into the bearing surface. The additives in high quality lubricating oils are also effective in protecting copper-lead bearings in internal combustion engines.

The combination of good high temperature properties, fatigue strength and load carrying capacity has resulted in considerable use of copper-lead materials for the main bearings and connecting rod bearings of internal combustion engines. They are also used to some extent at moderate loads and speeds in electric motors, turbines and steam engines.

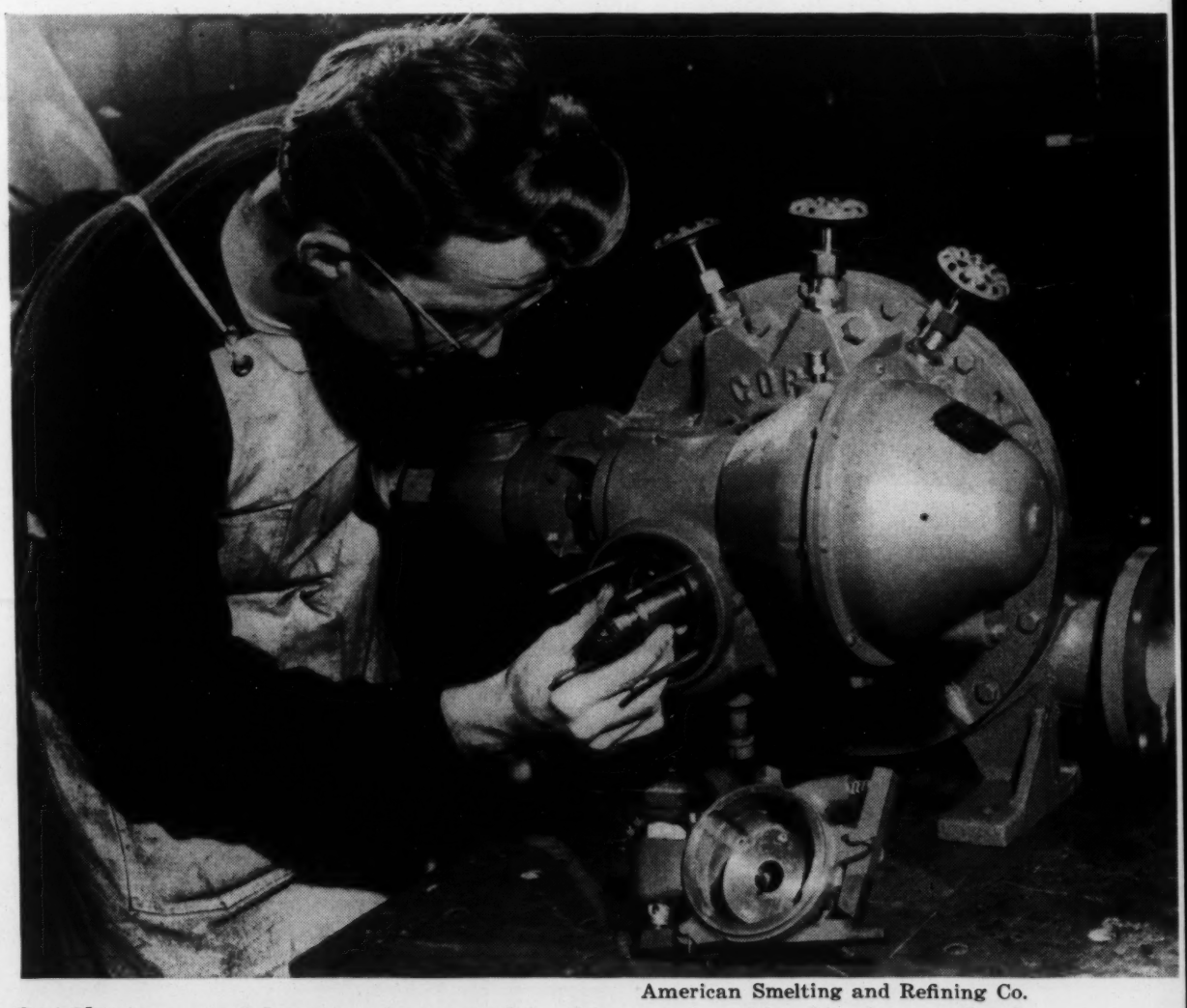
Leaded bronze

The wide popularity of cast bronze bearings (porous bronze bearings are discussed in a later section) stems from their: 1) adequate bearing properties, 2) excellent casting and machining characteristics, 3) comparatively low cost, and 4) ability to be used alone without an overlay or bond. Bronze bearings can be produced from standard bar



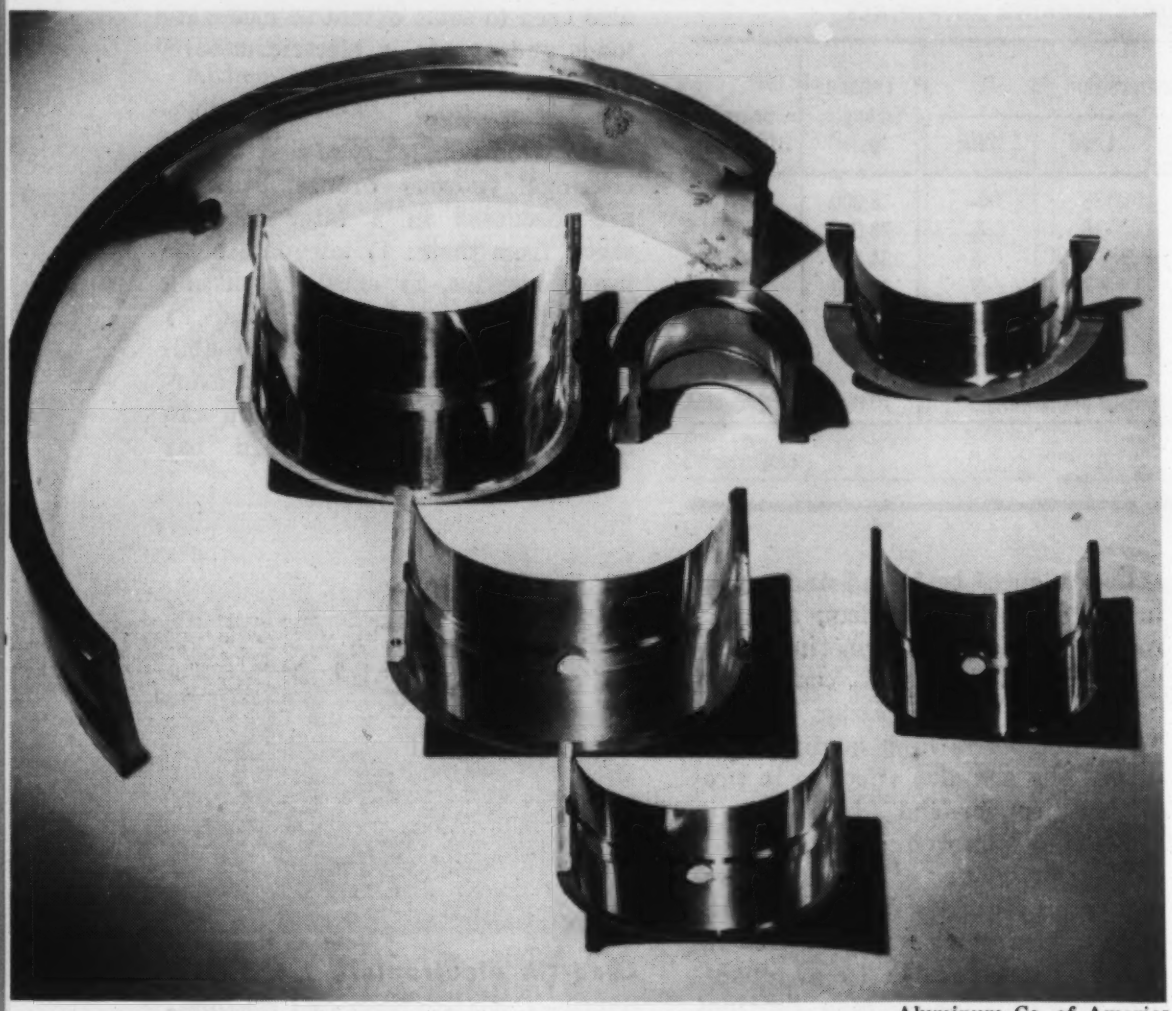
Johnson Bronze Co.

***Lead-tin electroplate** 1 mil thick improves compatibility and conformability of these steel-backed copper-lead sleeve bearings.*



American Smelting and Refining Co.

***Continuous cast bronze** sleeve used in this steam turbine has better physical properties and is less expensive than previous sand cast bronze sleeve.*



Aluminum Co. of America

Aluminum alloy *bearings have proved successful in internal combustion engines because of their corrosion resistance and their good load-carrying capacity, fatigue resistance and thermal conductivity.*

stock, or by sand, permanent mold, investment, centrifugal or continuous casting.

The leaded bronzes consist of a copper-tin matrix containing 4 to 24% lead held in mechanical suspension. The tin provides better strength, fatigue resistance and hardness than are possible with simple copper-lead mixtures. Zinc is sometimes used as a replacement for the tin, and nickel or nickel and silver are often added to improve corrosion resistance.

Leaded bronze has better compatibility than tin bronze because of the tendency of the spheroids of lead to smear over the bearing surface under conditions of inadequate lubrication. However, leaded bronze has somewhat lower strength and fatigue resistance than the tin bronze. Consequently, leaded bronze is used in applications requiring a compromise between copper-lead and tin bronze bearings, primarily at intermediate loads. Typical applications are light duty machinery, home appliances, farm machinery, pumps, thrust washers and FHP motors.

The SAE 660 leaded bronze alloy is available in hundreds of sizes for shafts ranging from about 3/16 to 4 in. A softer bronze, such as SAE 67 which contains more lead, is sometimes preferred where better compatibility is needed. Such a material is widely used for diesel engine bearings.

The 80 copper-10 tin-10% lead phosphor bronze is also popular. This material has good impact resistance and a relatively high hardness of 65 Bhn. It is widely used in steel plants for applications such as roll neck bearings, and is also used in lathes, instruments, household appliances, heavily loaded diesel rocker arm bushings, pumps, and automotive piston pin bushings.

Tin bronze

A tin bronze generally contains from 10 to 20% tin with just enough lead to aid in machining. Small amounts of zinc and/or nickel are sometimes added to improve strength. Suitable alloying can produce hardness values as high as 170 Bhn. Such a hardness level, however, is accompanied by brittleness and poor bearing properties.

Tin bronzes do not have particularly good bearing properties and consequently are usually used at low speeds. They require good alignment, reliable lubrication, and a minimum shaft hardness of 300 to 400 Bhn.

The SAE 62 gun metal alloy listed in Table 8 is one of the tin bronzes most commonly used for bearings. The high strength of this material enables it to be used in thin sections without any backing. This alloy is used as a bearing for such engine parts as connecting rods, piston pins, valve guides, fuel pumps and starters, and it is also used as a structural bearing in movable bridges and hydraulic machinery.

High strength bronzes

These bronzes contain various quantities of aluminum, iron, manganese, silicon, zinc and nickel. They have excellent shock and wear resistance, and their hardness ranges above 200 Bhn. They can usually withstand temperatures of more than 500 F.

High strength bronzes such as the SAE 68 aluminum bronze listed in Table 8 are best suited for heavy duty applications at low speeds. They are not satisfactory for high speed operation, and plentiful lubrication must be supplied to prevent overheating. High strength bronzes have been successfully used for heavy duty roll neck bearings and severe gear applications in steel mills.

Aluminum

Aluminum alloy bearings have proved quite successful in internal combustion engines because of their excellent resistance to corrosion by acidic oils, good load-carrying capacity, superior fatigue resistance and good thermal conductivity. Other than engines, relatively few applications have been developed for aluminum bearings in industrial equipment.

Two principal kinds of aluminum alloys are available for bearings. The most common alloy contains 6.5 tin-1 nickel-1% copper (Alcoa 750). This is a casting alloy in which the tin provides improved bearing properties and the small amounts of copper and nickel provide increased strength, hardness and scuff resistance. Ordinarily this alloy is used without an overlay. A very similar wrought alloy is also available; it has the same microconstituents plus a 1.5% silicon content which enables it to be rolled into shape.

The second major aluminum alloy

bearing material contains 4% silicon and 1% cadmium. This alloy is used in making steel-backed bearings with a babbitt-type lead-tin overlay. The overlay appears to provide better conformability and compatibility during initial engine operation, and better embeddability than uncoated aluminum surfaces. However, uncoated surfaces have proved very satisfactory, and the need for a babbitt overlay has not been definitely established.

Despite the increased use of aluminum alloy bearings in reciprocating engines, their use in other industrial equipment where the bearings are subject to a unidirectonal load has not been too successful. Trials have been made in FHP and larger motors, gear sets, railroad cars and steam turbines with limited success. In some cases there have been improvements in life, high temperature operation and cost as compared to previously used babbitt or bronze bearings. Good results have also been obtained in roll neck bearings in steel mills where aluminum has replaced cadmium and other bearing alloys to some extent. However, there have also been unexplained failures and difficulties caused by: 1) lack of sufficient embeddability and conformability, 2) the need for hardened shafts and improved surface finish, and 3) relatively poor compatibility characteristics, which lead to shaft damage when the oil supply is interrupted.

Aluminum-tin

Promising high tin aluminum alloys have been developed in England; these combine the desirable properties of aluminum and tin. Production bearings for internal combustion engines consist of 20% tin and 1% copper alloyed with the aluminum, and are backed with steel. The bearings are said to be useful with an unhardened steel shaft under heavy loads. At 300 F they have over twice the fatigue strength of tin babbitt. Unbacked aluminum-tin bearings are also under trial in rolling mill bearings and in subway cars. Some half-million of the aluminum-tin bearings are now in use and they are claimed to be cheaper to produce than previously used bearings.

Porous bronze *bearings can be used in such heavy duty applications as this large-diameter bearing used inside of a flywheel.*

Amplex Div., Chrysler Corp.

Silver

Silver overlay bearings are noted for their outstanding metallurgical uniformity and fatigue resistance, and for their excellent load capacity, thermal conductivity and high temperature characteristics. Because of these properties, they are extensively used in aircraft engines and similar heavy duty reciprocating engines. Two principal disadvantages of silver bearings are their poor embeddability and conformability. Although these properties can be improved by using a lead or tin overlay, silver bearings are nevertheless limited to applications where misalignment and dirt are not encountered. Another disadvantage of silver bearings is their comparatively high cost.

Most silver bearings are of a three-layer type with a steel backing and a tin or lead overlay. The prepared steel surface is first electroplated with a very thin layer of copper or nickel, and then electroplated with silver. After plating, the bearing is annealed at about 950 F to set the bond and recrystallize the silver. It is then covered with a 0.0004 to 0.005-in. overlay of lead, lead-tin mixture, or a tin-copper plate. If lead is used the bearing is given a final flash coat of indium which diffuses into the lead and prevents corrosion from lubricating oils.

The use of overlays over silver can be eliminated where good compatibility is required. The excellent compatibility of silver is generally attributed to the lack of wetting of steel by molten silver, and the absence of mutual solubility. These factors minimize the transfer of silver to mating surfaces which could cause welding and seizing. As shown in Table 2, a silver plate bearing running against steel exhibits a low wear rate, excellent dwell characteristics, and a complete absence of pickup. These results indicate the utility of silver where inadequate lubrication exists.

Porous metals

A porous bearing consists of a pressed and sintered bronze or iron powder which contains 10 to 40% pores by volume for storing lubricating oils. The materials are self-

lubricating in that oil flows through the interconnected pores to the surface to provide an oil film between the shaft and the bearing. There is only a minor degree of oil leakage since the lubricant is reabsorbed into the bearing by capillary action and also upon cooling when the shaft stops rotating.

Aside from self-lubricating properties, other advantages of porous metal bearings are: 1) they can be readily produced in large quantities, 2) their dimensions can be accurately controlled with little or no finish machining, and 3) their cost is low. Over 1000 sizes of porous bearings are available in bores ranging from 1/8 to 4 in. Wall thicknesses vary from 1/32 to 1/4 in.

Porous bronze

The most commonly used metal powder bearing consists of a bronze containing 90% copper and 10% tin. The bearing contains about 20% voids which are impregnated with an oil having a viscosity equivalent to an SAE 30 motor oil. Graphite is sometimes added to the bronze to improve self-lubricating properties.

The load-carrying capacity of porous bronzes, as well as plastics and other semi-lubricated bearing materials, can be expressed by a PV factor which is an index of the heat generated by friction on the bearing surface; P is the load in psi and V is the surface velocity of the shaft in fpm. As shown in Table 9, the PV limit of small porous bronze journal bearings is about 20,000. Higher values are sometimes quoted, particularly for bearings that are pressure-lubricated. For porous metal thrust bearings, a maximum PV value of 10,000 has been suggested.

Porous bronze bearings are used in large quantities in such applications as household appliances, electric fans, FHP motors, instruments, machine tools, agricultural equipment, office machinery and controls. In most applications the initial supply of oil in a prelubricated porous bearing is sufficient. However, supplementary lubrication is desirable where continuous operation is encountered for extended periods. In such cases, additional oil or grease can be supplied from a reservoir in the housing or by using a suitable wicking arrangement.

TABLE 9—OPERATING PROPERTIES OF POROUS METAL AND NONMETALLIC BEARINGS

Material ↓	Load Capacity, psi	Max Temp, F	Max Speed, fpm	PV Limit
Porous Metals	4,000	150	1,500	20,000
Nylon	1,000	170	500	2,000[b]
Phenolics	6,000	200	2,500	15,000
Teflon	500	500	250	1,000
Rubber	50	150	4,000	—
Wood	2,000	150	2,000	15,000
Graphite Materials	600	700	2,500	15,000 dry, 150,000 lubricated

[a]P=load in psi, V=surface speed in fpm. [b]For continuous operation with initial oil operation.

Porous iron

Porous iron bearings contain up to 10% copper and have about 20 to 25% voids. They are cheaper and can carry higher loads than porous bronze bearings, but they require more attention to secure an adequate supply of lubrication. The PV factor of porous iron bearings is about 50% higher than that of porous bronze. However, the surface speed limit of porous iron is about one-third lower—800 fpm as compared to 1200 to 1500 fpm for porous bronze.

Cast iron and steel

Cast iron has been used with some success as an inexpensive bearing material for low speed and low load applications. In such cases the bearing surface is generally machined directly into the cast iron structure of the machine. Typical applications are cam shafts, light transmissions, pivots, and lightly loaded machine journals.

A cast iron bearing develops a surface glaze from the flake graphite inherent in the material. This glazed surface offers support for a slowly rotating shaft so long as surface speeds are kept below 130 fpm and loads are kept below 450 to 500 psi (75 to 150 psi for small electric motors). Higher speeds can be used if good lubrication, close alignment and freedom from dirt are provided (e.g., refrigerator compressors). If such conditions are not maintained, operation is unreliable and seizure may occur suddenly and produce severe shaft damage.

Steel bushings and bearings are occasionally employed because of their low cost and easy machinability. They are used as guide bushings and as lightly loaded journal bearings where loads are kept below 200 psi and speeds are under 150 fpm.

Nonmetallic bearing materials

Many nonmetallic materials are now available for bearing applications. Almost every nonmetallic material has some special characteristic, whether it be self-lubricating properties or low cost, that warrants its selection over a metal bearing in certain specialized applications. The operating characteristics and cost of commonly used nonmetallic bearings are summarized in Tables 3, 4, 5, 6 and 9.

Plastics

Plastics are probably the most widely used nonmetallic bearing materials. Many new applications have been developed to suit the special characteristics of the materials. In addition, plastics have replaced older bearing materials in many applications.

Phenolics

Cotton-reinforced phenolic laminates have exceptionally good bearing characteristics. They are noted for their low wear and coefficient of friction, their good compatibility, and their ability to operate well with oils, greases or water. Because of their high resiliency they stand up well under severe impact and shock loads. Also, they require less machining than metal bearings.

Phenolic bearings can carry loads up to 7000 psi in semistatic applica-

tions such as electrical switchgear, but in heavy duty service they must be well cooled with an adequate supply of water or lubricating oil to carry away frictional heat. Heat generated in phenolic bearings is not readily dissipated because of the material's low thermal conductivity.

Because of their good mechanical properties, reinforced phenolics are frequently used as structural bearings in small devices such as clock motors, electrical panels and appliances. They can also be used in larger bearings such as rolling mill roll neck bearings, and marine and pump bearings. In the larger sizes, larger clearances than normal must be provided to allow for swelling and warping of the material when it is immersed in water. In some seals and water bearings, the cotton cloth filler is replaced with asbestos to provide greater stability.

Nylon

As shown in Fig 1 and Table 3, nylon bearings perform exceptionally well with little or no lubrication. However, loads and speeds must be kept below certain limits so that the surface of the material does not melt. As shown in Table 10, melting point of the material is 485 F. If melting occurs, the nylon has a strong tendency toward pick-up on a shaft and produces rapid self-destruction.

Synthane Corp.

Cotton-base phenolic *bearings have low coefficient of friction and long life. They are unaffected by oil.*

Nylon is harder, stronger and more resistant to abrasion and deformation than Teflon at room temperature. However, the reverse is true at elevated temperatures. (For further information see "Teflon and Nylon Bearing Materials," MATERIALS & METHODS, Mar '56, p 100.)

Cold flow of nylon can be a problem in moderate load applications where accurate dimensional control is required. However, this difficulty can often be minimized by using a thin liner of the material in a well supported metal sleeve. Use of nylon in thin sections also minimizes the problem of heat dissipation which results from the material's low thermal conductivity.

Nylon is used for small, lightly loaded bearings in appliances, toys, and photographic and food processing equipment, and in mechanisms operating in water, milk, gasoline and solvents. Also, nylon has replaced wood and other bearing materials in many household applications. Examples are the supporting wheels for appliance drawers, shelves and baskets, and supports for traverse rods and sliding doors.

Teflon

The most important characteristics of Teflon for bearing applications are its corrosion resistance and its low coefficient of friction. The friction coefficient can be as low as 0.04 or even lower; this compares with values of 0.09 to 0.12 for such familiar dry lubricants as molybdenum disulfide and graphite. As shown in Table 10, the compressive and tensile strengths of Teflon are not as great as for nylon. However, Teflon has good high temperature stability; it can be used continuously up to about 500 F, and intermittently up to 620 F.

Teflon is soft and tough and will embed most hard foreign particles. Under relatively light loads and low speeds, unmodified Teflon has adequate wear resistance. Under severe conditions, reinforcing materials such as graphite or powdered glass provide additional wear resistance. Teflon-glass combinations have shown wear rates 100 times better than unfilled Teflon. Although filled Teflon has a somewhat higher coefficient of friction and better resistance to deformation than unfilled material, the addition of reinforcing materials does not greatly alter its physical properties. Unmodified Teflon should be used at PV values below 1000 when applied over a wide range of loads and speeds. Filled combinations can be used at PV values as high as 5000. Higher values can be used at low speeds.

Teflon has also been used with good results in a composite bearing. This bearing consists of a tin-plated steel backing on which is sintered a thin lining of spherical bronze impregnated with a mixture of Teflon and lead. This composite bearing has several outstanding advantages, including: 1) the high wear resistance of lead-filled Teflon and bronze, 2) low coefficient of friction, 3) the high thermal conductivity of bronze, 4) the low thermal expansion of bronze and steel, 5) high strength (compressive yield strength is 46,000 psi) and hardness, 6) a usable temperature range from −328 to +536 F, and 7) high resistance to chemicals and corrosion.

TABLE 10—PROPERTIES OF NYLON[a] AND TEFLON BEARING MATERIALS

Material ➡	Nylon[a]	Teflon
Melting Point, F	485	620
Coef of Ther Exp, °F	5.5 x 10-6	5.6 x 10-5[b]
Ther Cond, Btu/hr/sq ft/ °F/in.	1.7	1.7
Hardness		
Rockwell	R118	R25
Knoop	6.5	2.8
Durometer	—	D50-65
Tensile Strength, psi		
60 F	14,000	5,000
73 F	9,300	3,000
190 F	6,000	1,500
Compressive Strength (1% def), psi	2,500	600
Fatigue Endurance Limit, psi		
73 F	3,000	760
212 F	2,000	—
Max Rec Svc Temp, F		
Continuous	170[c]	500
Intermittent	—	670

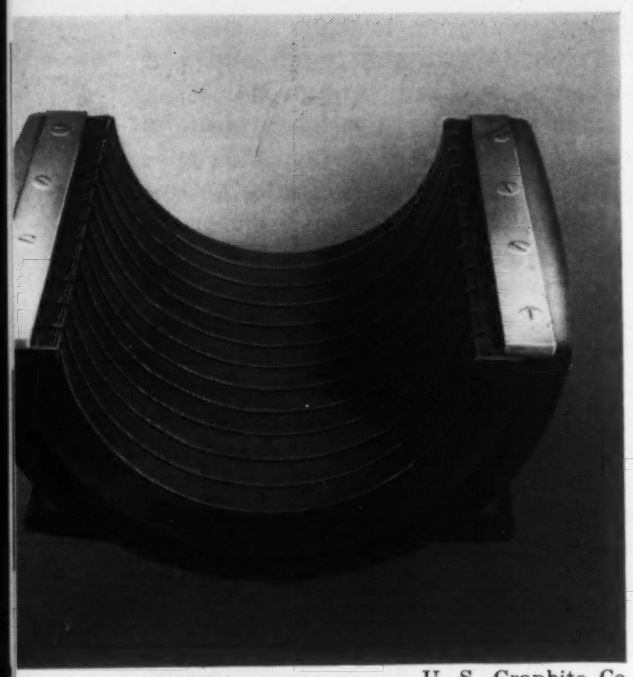
[a]Values given are for Zytel 101 (FM-10001) conditioned to average air exposure.
[b]Transition point at 70 F results in linear increase of 0.004 in. per in.
[c]For continuous use at temperatures above 170 F a heat stabilized composition is recommended which retains properties for over 50,000 hr at 250 F, and for 2000 hr at 300 F.

Other nonmetallic materials

Carbon-graphite

Carbon-graphite bearings are distinguished by their inherent lubricity and high wear resistance at high temperatures where lubrication cannot be provided. Because of their self-lubricating properties they can be used in contact with low viscosity fluids such as water, gasoline, solvents and refrigerants. Typical applications are water and gasoline pumps, submersible motors, oven and furnace conveyors, telephone switchboard equipment, and high temperature bushings for aircraft.

Carbon-graphite bearings are made from finely ground powders of coke, carbon and graphite mixed with a pitch binder. The powder is molded under high pressure to con-



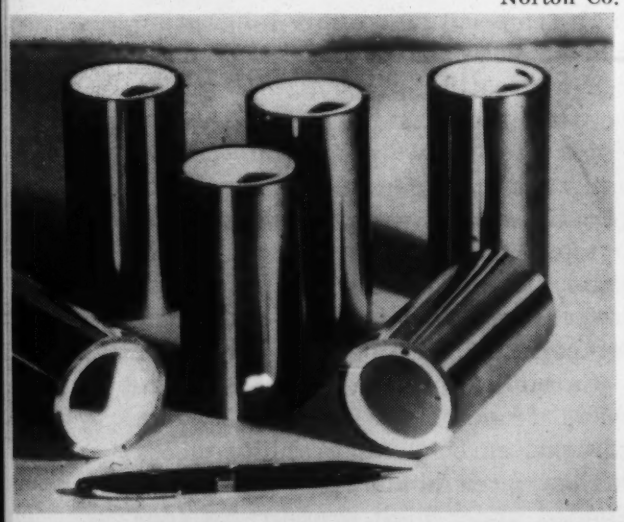
U. S. Graphite Co.

Carbon-graphite *bearings possess inherent lubricity which allows them to be used in contact with low viscosity fluids such as water, gasoline, solvents and refrigerants.*

trol porosity, and the molded piece is then fired at a high temperature to bond the materials and form the final structure. After firing, the bearing may have a porosity of 5 to 20%. The pores can be filled with a phenolic resin, oil, or metals such as silver, copper, bronze, cadmium or babbitt. Within this broad range of composition, bearings can be produced with a wide variation in hardness, strength and performance characteristics. The wide variations obtainable in compatibility properties are shown in Table 4, it is recommended that PV values of carbon-graphite bearings be held below 12,000 to 15,000 when dry and 150,000 when lubricated.

Aluminum oxide *ceramic materials can be used where a very hard and wear resistant bearing surface is needed.*

Norton Co.



Several precautions must be observed with carbon-graphite bearings. Although they are reasonably strong and resilient, they are easily chipped or cracked if struck on an edge or corner, or if they are subjected to high thermal, tensile or bending stresses. For these reasons, and because of their extremely low coefficient of expansion (about one-fourth that of steel), carbon-graphite bearings are often shrunk into a metal sleeve. Wherever possible, sharp corners at the edges of bearings or in keyways should be avoided because they produce stress concentration which can result in cracking.

Rubber

Rubber bearings are particularly well suited for use in water and have provided excellent performance on the propeller shafts of ships and in hydraulic turbines, deep well pumps, gravel washers and other devices. The softness and resilience of rubber allow sand and dirt particles to pass right through the bearing-journal interface. In water bearing applications, rubber also provides low friction, resists abrasion quite well, is shock absorbent, and provides long life.

Rubber bearings are often made in the form of longitudinal strips which are supported in a metal shell. This construction allows the shaft to be carried on the edges of the flutes which run the length of the bearing. Water circulating between the strips cools the bearing and flushes away any foreign matter. The maximum load that can be applied to the rubber is about 50 psi.

Wood

Lignum vitae, oak and oil-impregnated maple have been extensively used as bearing materials for many centuries. Wood bearings have good self-lubricating properties and long life, are clean in operation, and are low in cost. Wood has been replaced in many applications by other non-metallic materials; however, it can be used to great advantage in specialized applications.

Wood is still being used at temperatures up to 150 F. Most of these applications are under wet operating conditions, as in food processing and chemical plants. Wood is also used in some conveyor, machinery and marine applications.

Carbides and ceramics

Pressed and sintered particles of tungsten carbide in a cobalt matrix provide a very hard (about Rockwell C80) and wear resistant bearing material. The material has a high modulus of elasticity and rigidity and can be given an excellent surface finish. With this combination of properties, clearances can be held to a few ten-thousandths of an inch for accurate location of journals in devices such as high speed precision grinders.

The extremely high wear resistance of the material has also made it useful in pivots, cams and other sliding surfaces under high loads. Although high hardness is not normally regarded as a desirable property in bearing materials, cemented carbides have solved some difficult bearing problems where softer materials proved inadequate.

Fused aluminum oxide and boron nitride ceramics are also occasionally used where a hard and wear resistant bearing surface is needed. However, aside from specialized uses, wide-spread application of ceramic bearings is unlikely because of their poor compatibility and conformability, and their high cost. It is possible that ceramic-coated metal bearings may have some future application.

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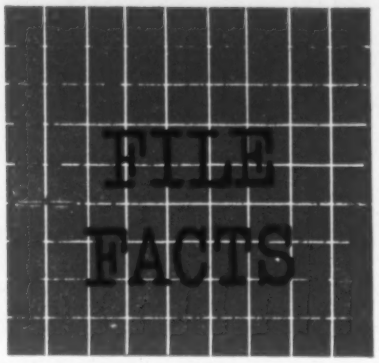
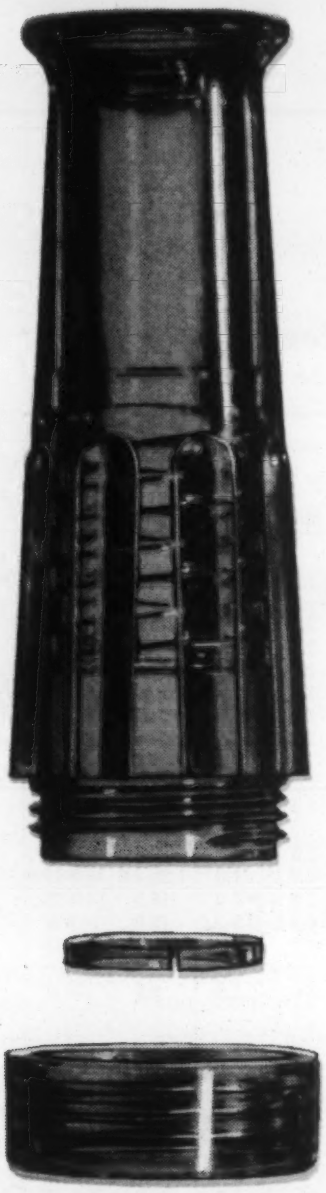


Government Specifications for Stainless Steel

Specification (s=supersedes)		Nearest Corresponding Specification			Composition, %							Form
		SAE	AISI	AMS	C[a]	Mn[a]	Si[a]	Ni[b]	Cr[b]	Mo[b]	Other	
U. S. MILITARY SPECIFICATIONS												
MIL-S-853A (Ships) s MIL-S-853 (Ships)	Class 1, Types A, B, C	30304	304	5639	0.08	2.0	1.0	8.0	18.0	—	—	Bars and forgings (except for reforging; for reforging bars and billets see MIL-S-862A)
	Class 2, Types A, B, C	30302	302	5636A, 5637A	0.09–0.20	2.0	1.0	8.0	17.0	—	—	
	Class 3, Types A, C, E, F	51410	410	5613C	0.15	1.0	1.0	0.6 max	11.5–13.5	0.6	—	
	Class 4	51430	430	5627	0.12	1.0	1.0	0.5 max	16.0–18.0	0.6	—	
	Class 5, Types A, F	51420	420	5620B, 5621	0.30–0.40	1.0	1.0	0.5 max	12.0–14.0	—	—	
	Class 6, Types A, C, E	51416	416	5610E	0.15	1.2	1.0	0.5 max	12.0–14.0	0.6[c]	See spec	
	Class 7, Types A, B, C	30303F	303	5640E, 5641A, 5742	0.15	2.0	1.0	9.0	17.0	0.75[c]	Zr 0.75 max[c]	
	Class 8, Type A	30321 or 30347	321 or 347	5645F, 5646D	0.08	2.0	1.0	8.0	17.0	—	Ti 5×C min or Cb-Ta 10×C min	
	Class 9, Types A, C	30317	317	—	0.10	2.0	1.0	10.0	16.0–18.0	2.0	—	
	Class 10, Types A, E, F	51431	431	5628B	0.20	0.8	1.0	1.25-2.0	15.0–17.0	—	—	
	Class 11, Type A	30310	310	5651C	0.25	2.0	2.0	19.0	24.0–26.0	—	—	
	Class 12	30325	325	—	0.50	0.4–0.8	0.5–2.0	19.0	6.5	—	—	
	Class 14, Types A, E, F	—	—	—	0.08	0.7	0.75	4.0–8.0	16.0–18.0	[c]	—	
MIL-S-854 (Ships) Amend 4 s 47S20 (INT)	Class 1, Cond A	30304	304	5513	0.08	2.0	1.0	8.0	18.0	—	—	Plate, sheet, strip, shapes
	Class 2, Cond A, B, C, D, E	30302	302	5515C, 5516E, 5517D, 5518C, 5519E	0.09–0.20	2.0	1.0	8.0	17.0	—	—	
	Class 3, Cond A	51410	410	5504C	0.15	1.0	1.0	0.8 max	11.5–13.5	—	—	
	Class 4, Cond A	51430	430	—	0.12	1.0	1.0	0.6 max	16.0–18.0	—	—	
	Class 8, Cond A	30321 or 30347	321 or 347	5510E, 5512B	0.08	2.0	1.0	8.0	17.0	—	Ti 5×C min or Cb 10×C min	
	Class 9, Cond A	30316	316	5524B	0.10	2.0	1.0	10.0	16.0–18.0	2.0–3.0	—	
	Class 11, Cond A	30310	310	5521B	0.25	2.0	2.0	19.0	24.0–26.0	—	—	
MIL-S-861A (Ships) s MIL-S-861 (Ships)	Class 403	—	403	—	0.15	1.0	0.5	—	11.5–13.0	See spec	—	Bars
	Class 410	51410	410	5613C	0.15	1.0	1.0	—	11.5–13.5	—	—	
	Class 405	—	405	—	0.08	1.0	1.0	—	11.5–13.5	—	Al 0.10–0.30	
	Class 422	—	—	—	0.18–0.23	1.0	1.0	0.5–1.0	12.0–14.0	0.75–1.25	V 0.20–0.50, W 0.75–1.25	
MIL-S-862A s MIL-S-862 (Ships)	Classes similar to MIL-S-853A (Ships)	See MIL-S-853A (Ships)			Analyses similar to those shown for MIL-S-853C (Ships)							Bars and billets (for reforging only)
MIL-P-1144A (Ships) used in lieu of JAN-P-1144	Comp 304	30304	304	—	0.08	2.0	0.75	8.0	18.0	—	—	Seamless and welded pipe
	Comp 316	30316	316	—	0.08	2.0	0.75	11.0	16.0	1.75–2.50	—	
	Comp 321 or 347	30321 or 30347	321 or 347	—	0.08	2.0	0.75	9.0	17.0	—	Ti 5×C min or Cb-Ta 8×C min	
MIL-S-4043 (USAF) Amend 1	—	—	304L	5511A	0.03	2.0	1.0	8.0–11.0	18.0–20.0	0.5	—	Plate, sheet, strip
MIL-S-5059A (ASG) Amend 1 s MIL-S-5059	Comp 301	30301	301	5515C, 5517D, 5518C, 5519E	0.12	2.0	1.0	6.5	17.0	0.5	—	Plate, sheet, strip
	Comp 302	30302	302	5513, 5516E	0.12	2.0	1.0	8.0–11.0	17.0–20.0	0.5	—	
	Comp 316	30316	316	5524B	0.08	2.0	1.0	10.0–14.0	16.0–18.0	1.75 min	—	
MIL-T-5695B (ASG) s MIL-T-5695A	—	30304	304	5560C, 5565C, 5566C	0.08	2.0	0.75	8.0–11.0	18.0–20.0	0.7	—	Seamless and welded tubing
MIL-W-6713 s AN-W-24	Grade G, Cond A, B	30302	302	5688C	0.12	0.2–2.5	0.2–1.5	7.0	17.0	—	—	Wire
MIL-S-6721A s MIL-S-6721	Comp Ti	30321	321	5510E	0.08	2.0	1.0	8.0–11.0	17.0–19.0	—	Ti 6×C min, 0.75 max	Plate, sheet, strip
	Comp Cb	30347	347	5512B	0.08	2.0	1.0	9.0–13.0	17.0–19.0	—	Cb 10×C min, 1.15 max	
	Comp Cb-Ta	30347	347	5512B	0.08	2.0	1.0	9.0–13.0	17.0–19.0	—	Cb-Ta 10×C min, 1.25 max	
MIL-T-6737A (ASG) Amend 2 s MIL-T-6737	Comp 347	30347	347	5575E	0.08	2.0	1.0	9.0–13.0	17.0–20.0	—	Cb or Cb-Ta 10×C min, 1.10 max	Welded tubing
	Comp 321	30321	321	5576A	0.08	2.0	1.0	9.0–13.0	17.0–20.0	—	Ti 5×C min, 0.75 max	
MIL-T-6845 Amend 5 s AN-T-86	—	30304	304	5566C	0.08	2.0	0.75	8.0	18.0	0.5	—	Seamless and welded tubing—hydraulic
MIL-T-6846 Amend 1 s AN-T-43	—	30304	304	5566C	0.08	2.0	0.75	8.0	18.0	0.5	—	

For more information, circle No. 515



Four parts of **TENITE BUTYRATE** form this tough, lightweight nozzle

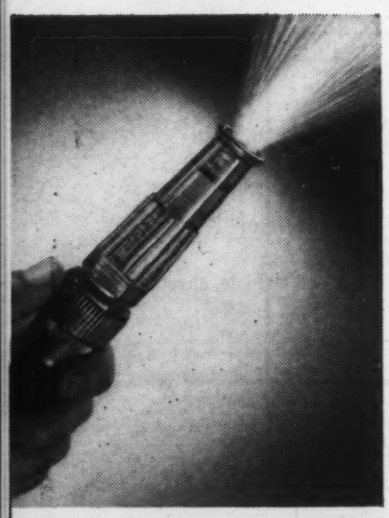
Here's a good example of how a switch to Butyrate plastic can mean an improved product, with savings in both material and manufacturing costs.

Four parts of transparent green Tenite Butyrate make up this product. Assembled in an adjustable, leakproof fit, they form an attractive and durable hose nozzle which sells at a popular price.

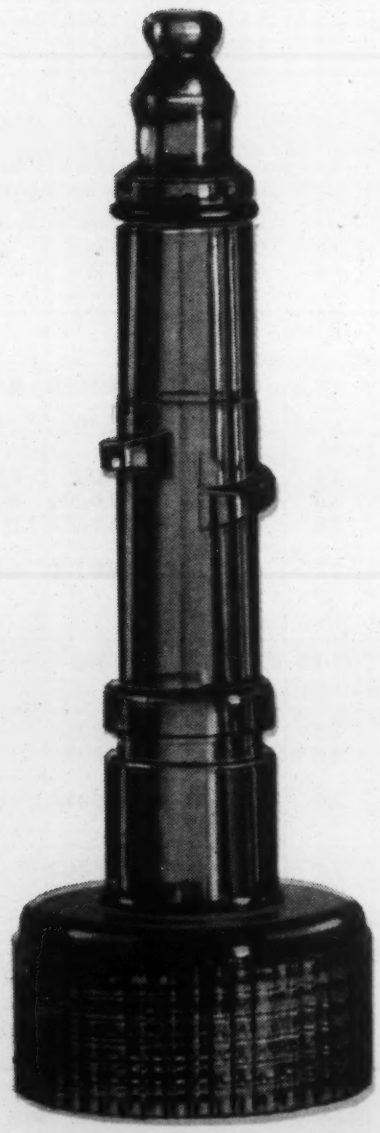
These four plastic parts, including the threads, were injection molded in one quick operation. The "manufacturing" process consisted only of molding and assembly. By avoiding use of metallic parts, there was no casting, no forging, and no machining, even for the threads.

And look how well Tenite Butyrate meets the performance needs: It is a tough plastic, virtually shatterproof and ready to take a good measure of abuse; yet, it's light in weight. It resists corrosion and endures outdoor exposure over broad variations in temperature and humidity. Color is an integral part of the product and will not chip off or wear away. Tests show the assembled nozzle has withstood water pressures up to 500 psi.

Remember this use of Butyrate whenever you need a tough, outdoor plastic, readily adaptable to design. Tenite Butyrate is available in a wide range of flows and colors for injection molding or continuous extrusion. Look into the design and economy possibilities offered by this versatile plastic. For more information on Tenite Butyrate or any other Eastman plastic, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.



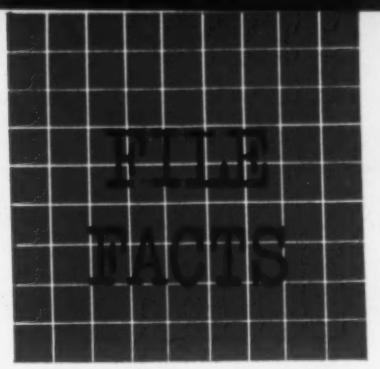
Trans-Flo hose nozzle molded of Tenite Butyrate by The Vlchek Tool Company, Cleveland 4, Ohio.



TENITE

BUTYRATE · ACETATE · POLYETHYLENE

plastics by Eastman



Government Specifications for Stainless Steel—continued

Specification (s=supersedes)		Nearest Corresponding Specification			Composition, %							Form
		SAE	AISI	AMS	C[a]	Mn[a]	Si[a]	Ni[b]	Cr[b]	Mo[b]	Other	
U. S. MILITARY SPECIFICATIONS—continued												
MIL-S-7720 Amend 1 s AN-S-771	Comp 302	30302	302	5636A, 5637A, 5639	0.12	2.0	1.0	8.0–11.0	17.0–20.0	—	—	Bars, forging stock
	Comp 303S	30303F	303	5640E, 5641A, 5742	0.12	2.0	1.0	8.0	17.0–20.0	0.6	P+S min 0.18	
	Comp 303Se	30303F	303Se	5640E, 5641A, 5742	0.12	2.0	1.0	8.0	17.0–20.0	0.6	Se 0.15–0.35	
	Comp 316	30316	316	5648B, 5649	0.08	2.0	1.0	10.0–14.0	16.0–18.0	1.75–3.0	—	
MIL-T-8504 (ASG) Amend 2 s MIL-T-6846	—	30304	304	5566C	0.08	2.0	0.75	8.0	18.0	0.5	—	Seamless and welded tubing—hydraulic
MIL-T-8506 Amend 1	—	30304	304	5560C, 5565C, 5566C	0.08	2.0	0.75	8.0–11.0	18.0–20.0	0.7	—	Seamless and welded tubing
MIL-T-8606 (ASG)	Comp G347	30347	347	5571A	0.08	2.0	1.0	9.0–13.0	17.0–20.0	—	Cb or Cb-Ta 10×C min, 1.00 max	
	Comp G321	30321	321	5570F	0.08	2.0	1.0	9.0–13.0	17.0–20.0	—	Ti 5×C min, 0.75 max	
MIL-T-8808	Comp G347	30347	347	5571A	0.08	2.0	1.0	9.0–12.0	17.0–19.0	0.5	Cb or Cb-Ta 10×C min, 1.10 max	Seamless and welded tubing—hydraulic
	Comp G321	30321	321	5570F	0.08	2.0	1.0	8.0–11.0	17.0–19.0	0.5	Ti 5×C min, 0.75 max	
MIL-S-17759 (Ships)	Cond A, B, C, H	—	17-10P	—	0.15	1.0	1.0	9.5–12.0	16.0–18.0	—	—	Bars, billets, forgings, wire
MIL-S-17996 (Ships)	Class 1	—	201	—	0.20	5.0–7.0	1.0	3.5–5.5	16.0–18.5	—	N 0.25 max	Sheet, other wrought forms
	Class 2	—	—	—	0.15	13.0–18.5	1.0	1.0 max	14.0–18.0	—	—	
MIL-T-18063 (Ships) Amend 1 (for radioactive svc)	Comp 304	30304	304	5560C, 5565C, 5566C	0.08	2.0	0.75	8.0	18.0	—	Co 0.2 max	Seamless and welded pipe and tubing
	Comp 304L	—	304L	5647	0.04	2.0	0.75	8.0	18.0	—	Co 0.2 max	
	Comp 347	30347	347	5570F, 5575E	0.08	2.0	0.75	9.0	17.0	—	Cb 8×C min, 0.85 max; Ta 0.10 max, Co 0.2 max	
MIL-S-18170 (Ships) Amend 3 (for radioactive svc)	Comp 304	30304	304	5639	0.08	2.0	1.0	8.0	18.0	—	Co 0.2 max	Bars and forgings (except for reforging)
	Comp 304L	—	304L	5647	0.03	2.0	1.0	8.0	18.0	—	Co 0.2 max; Cb 8×C min, 0.85 max	
	Comp 347	30347	347	5646D	0.08	2.0	1.0	9.0	17.0	—	Ta 0.10 max, Co 0.2 max	
MIL-S-18171 (Ships) (for radioactive svc)	Comp identical to MIL-S-18170 (Ships) Amend 3	See MIL-S-18170 (Ships) Amend 3			Analyses identical with those shown for MIL-S-18170 (Ships) Amend 3							Plate, sheet, strip
MIL-S-18732 (ASG) s AN-QQ-S-770a	—	51431	431	5628B	0.12–0.17	0.3–0.8	0.2–0.6	1.5–2.5	15.5–17.0	—	—	Bars
MIL-S-25043A (ASG)	—	—	17-7PH	5528, 5529	0.09	1.0	1.0	6.5–7.75	16.0–18.0	—	Al 0.75–1.50	Plate, sheet, strip
AIR FORCE–NAVY AERONAUTICAL SPECIFICATIONS												
AN-W-24	Grade G	30302	302	5688C	0.12	0.2–2.5	0.2–1.5	7.0	17.0	—	—	Wire
AN-S-757	Comp Ti	30321	321	5510E	0.08	2.0	1.0	9.0–12.0	17.0–19.0	—	Ti 6×C min	Plate, sheet, strip
	Comp Cb	30347	347	5512B	0.08	2.0	1.0	10.0–13.0	17.0–19.0	—	Cb-Ta 10×C min	
AN-QQ-S-770a Amend 1	—	51431	431	5628B	0.17	0.3–0.7	0.2–0.6	1.5–2.5	15.5–17.5	—	—	Bars
AN-S-771 Amend 1	Comp G	30302	302	5636A, 5637A	0.12	2.0	1.0	8.0–11.0	17.0–20.0	—	—	Bars
	Comp MCR	30316	316	5648B, 5649	0.10	2.0	1.0	10.0–14.0	16.0–18.0	2.0–3.0	—	
	Comp FMS	30303F	303	5640E, 5641A, 5742	0.12	2.0	1.0	8.0	17.0–20.0	0.6	P+S min 0.18	
	Comp FMP	30303F	303	5640E, 5641A, 5742	0.12	2.0	1.0	8.0	17.0–20.0	0.6	P+S min 0.18	
	Comp FM Se	30303F	303	5640E, 5641A, 5742	0.12	2.0	1.0	8.0	17.0–20.0	0.6	Se 0.15–0.35	
AN-QQ-S-772a Amend 1	Comp G	30302	302	5515C, 5516E, 5517D, 5518C, 5519E	0.12	0.2–2.5	0.2–1.5	6.5	17.0	—	—	Plate, sheet, strip
	Comp MCR	30316	316	5524B	0.10	0.2–2.5	0.2–1.5	7.0–14.0	17.0	1.75–2.5	—	
AN-WW-T-855 Amend 2	—	30304	304	5560C	0.12	0.2–2.5	0.2–1.5	7.0	17.0	—	—	Seamless tubing

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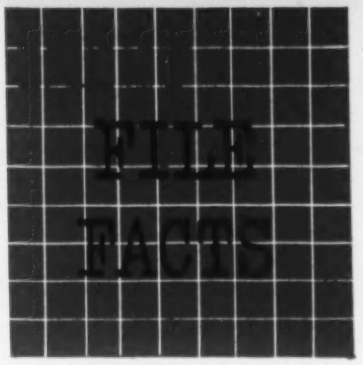

Government Specifications for Stainless Steel—concluded

Specification (s=supersedes)		Nearest Corresponding Specification			Composition, %							Form
		SAE	AISI	AMS	C[a]	Mn[a]	Si[a]	Ni[b]	Cr[b]	Mo[b]	Other	
AIR FORCE–NAVY AERONAUTICAL SPECIFICATIONS—continued												
AN-WW-T-858 Amend 2		30321 or 30347	321 or 347	5570F, 5571A	0.10	0.2–2.5	0.2–1.5	7.0	17.0	—	Ti 4×C min or Cb-Ta 8×C min	
FEDERAL SPECIFICATIONS												
QQ-W-4 3	Comp FS 302	30302	302	5688C	0.08–0.20	2.0	1.0	8.0–10.0	17.0–19.0	—	—	
	Comp FS 304	30304	304	5697	0.08	2.0	1.0	8.0–11.0	18.0–20.0	—	—	
	Comp FS 310	30310	310	—	0.25	2.0	1.5	19.0–22.0	24.0–26.0	—	—	
	Comp FS 316	30316	316	5690E	0.10	2.0	1.0	10.0–14.0	16.0–18.0	2.0–3.0	—	Wire
	Comp FS 410	51410	410	—	0.15	1.0	1.0	—	11.5–13.5	—	—	
	Comp FS 420	51420	420	—	>0.15	1.0	1.0	—	12.0–14.0	—	—	
	Comp FS 430	51430	430	—	0.12	1.0	1.0	—	14.0–18.0	—	—	
QQ-S-763b s QQ-S-00763a Rev 1 and MIL-S-854 (in part)	Class 202	—	202	—	0.15	7.5–10.0	1.0	4.0–6.0	17.0–19.0	—	N 0.25 max	
	Class 302	30302	302	5636A, 5637A	0.15	2.0	1.0	8.0–10.0	17.0–19.0	—	—	
	Class 303	30303F	303	5640E, 5641A, 5742	0.15	2.0	1.0	8.0–10.0	17.0–19.0	0.6[c]	Zr 0.6[c]	
	Class 303Se	30303F	303Se	5640E, 5641A, 5742	0.15	2.0	1.0	8.0–10.0	17.0–19.0	—	Se 0.15 min	
	Class 304	30304	304	5639	0.08	2.0	1.0	8.0–12.0	18.0–20.0	—	—	Bars, shapes, forgings
	Class 304L	—	304L	5647	0.03	2.0	1.0	8.0–12.0	18.0–20.0	—	—	
	Class 305	30305	305	—	0.12	2.0	1.0	10.0–13.0	17.0–19.0	—	—	
	Class 309	30309	309	5650	0.20	2.0	1.0	12.0–15.0	22.0–24.0	—	—	
	Class 310	30310	310	5651C	0.25	2.0	1.5	19.0–22.0	24.0–26.0	—	—	
	Class 316	30316	316	5648B, 5649	0.08	2.0	1.0	10.0–14.0	16.0–18.0	2.0–3.0	—	
	Class 316L	—	316L	—	0.03	2.0	1.0	10.0–14.0	16.0–18 0	2.0–3.0	—	
	Class 317	30317	317	—	0.08	2 0	1.0	11.0–15.0	18.0–20.0	3.0–4.0	—	
	Class 321	30321	321	5645F	0.08	2.0	1.0	9.0–12.0	17.0–19.0	—	Ti 5×C min	
	Class 322	—	17-7PH	5644	0.10	1.0	1.5	6.0–8.0[c]	16.0–18.0	—	Ti 1.5 max, Al 0.5 max	
	Class 324	—	17-4PH	5643C	0.07	1.0	1.0	3.0–5.0	15.5–17.5	—	Cb-Ta 0.15–0.4	
	Class 347	30347	347	5646D	0.08	2.0	1.0	9.0–13.0	17.0–19.0	—	Cb-Ta 10×C min	
	Class 350	—	—	—	0.08–0.12	0.50–1.25	0.5	4.0–5.0	16.0–17.0	2.5–3.25	N 0.07–0.13	
	Class 355	—	—	—	0.10–0.15	0.50–1.25	0.5	4.0–5.0	15.0–16.0	2.5–3.25	N 0.07–0.13	
	Class 403	—	403	—	0.15	1.0	0.5	—	11.5–13.0	—	—	
	Class 405	—	405	—	0.08	1.0	1.0	—	11.5–14.5	—	Al 0.1–0.3	
	Class 410	51410	410	5613C	0.15	1.0	1.0	—	11.5–13.5	—	—	
	Class 414	51414	414	5615B	0.15	1.0	1.0	1.25–2.50	11.5–13.5	—	—	
	Class 416	51416	416	5610E	0.15	1.25	1.0	—	12.0–14.0	0.6[c]	Zr 0.6 max[c]	
	Class 416 Se	—	416Se	5610E	0.15	1.25	1.0	—	12.0–14.0	—	Se 0.15 min	
	Class 420	51420	420	5620B, 5621	>0.15	1.0	1.0	—	12.0–14.0	—	—	
	Class 430	51430	430	5627	0.12	1.0	1.0	—	14.0–18.0	—	—	
	Class 430F	51430F	430F	—	0.12	1.25	1.0	—	14.0–18 0	0.6[c]	Zr 0.6 max[c]	
	Class 430F Se	—	430FSe	—	0.12	1.25	1.0	—	14.0–18.0	—	Se 0.15 min	
	Class 431	51431	431	5628B	0.20	1.0	1.0	1.25–2.50	15.0–17.0	—	—	
	Class 440A	51440A	440A	5631	0.60–0.75	1.0	1.0	—	16.0–18.0	0.75	—	
	Class 440B	—	440B	—	0.75–0.95	1.0	1.0	—	16.0–18.0	0.75	—	
	Class 440C	51440C	440C	5630C	0.95–1.20	1.0	1.0	—	16.0–18.0	0.75	—	
	Class 440F	51440F	440C	5632A	0.95–1.20	1.25	1.0	—	16.0–18.0	0.75	—	
	Class 440F Se	51440F	440C	5632A	0.95–1.20	1.25	1.0	—	16.0–18.0	0.75	Se 0.15 min	
	Class 446	51446	446	—	0.2	1.5	1.0	—	23.0–27.0	—	N 0.25 max	
QQ-S-00766b Amend 1 s MIL-S-854 (in part)	Class 201	—	201	—	0.15	5.5–7.5	1.0	3.5–5.5	16.0–18.0	—	N 0.25 max	
	Class 202	—	202	—	0.15	7.5–10.0	1.0	4.0–6.0	17.0–19.0	—	N 0.25 max	
	Class 301	30301	301	—	0.15	2.0	1.0	6.0	16.0	—	—	Plate, sheet strip
	Class 302	30302	302	5515C, 5516E, 5517D, 5518C, 5519E, [illegible]	0.15	2.0	1.0	8.0	17.0	—	—	
	Class 304	30304	304	5513 [illegible]	0.08	2.0	1.0	8.0	18.0	—	—	
	Class 304L	—	304L	5511A [illegible]	0.03	2 0	1.0	8.0	18.0	—	—	
	Class 305	30305	305	5514A [illegible]	0.12	2.0	1.0	10.0	17.0	—	—	
	Class 309	30309	309	5523 [illegible]	0.20	2.0	1.0	12.0	22.0–24.0	—	—	
	Class 310	30310	310	5521B [illegible]	0.25	2.0	1.5	19.0	24.0–26.0	—	—	
	Class 316	30316	316	5524B [illegible]	0.08	2.0	1.0	10.0	16.0	2.0–3.0	—	
	Class 316L	—	316L	—	0.03	2.0	1.0	10.0	16.0	2.0–3.0	—	
	Class 321	30321	321	5510E [illegible]	0.08	2.0	1.0	9.0	17.0	—	Ti 5×C min	
	Class 323	—	—	—	0.09	1.0	1.0	6.5–7.75	16.0–18.0	—	Al 0.75–1.5	
	Class 347	30347	347	5512B [illegible]	0.08	2.0	1.0	9.0	17.0	—	Cb 10×C min, 1.1 max	
	Class 348	—	348	—	0.08	2.0	1.0	9.0	17.0	—	Cb-Ta 10×C min, Ta 0.1 max	
	Class 410	51410	410	5504C	0.15	1.0	1.0	0.6 max	11.5–13.5	0.6	—	
	Class 430	51430	430	—	0.12	1.0	1.0	0.6 max	14.0–18.0	—	—	
	Class 446	51446	446	—	0.20	1.5	1.0	0.6 max	23.0–27.0	—	N 0.25 max	

[a]Maximum, except where otherwise stated or range is shown. [b]Minimum, except where otherwise stated or range is shown. [c]Optional.

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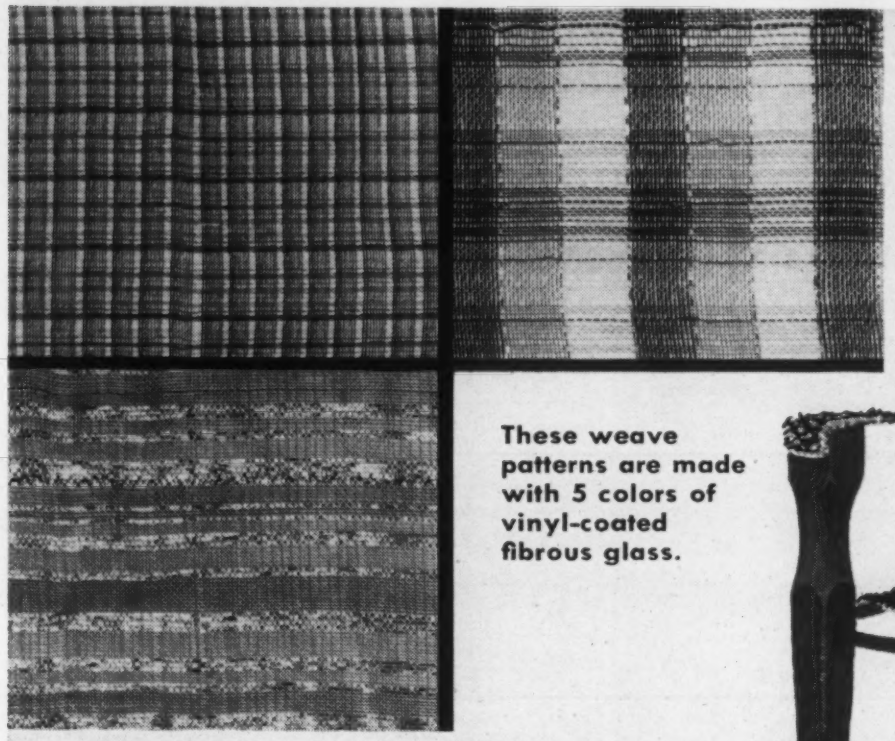

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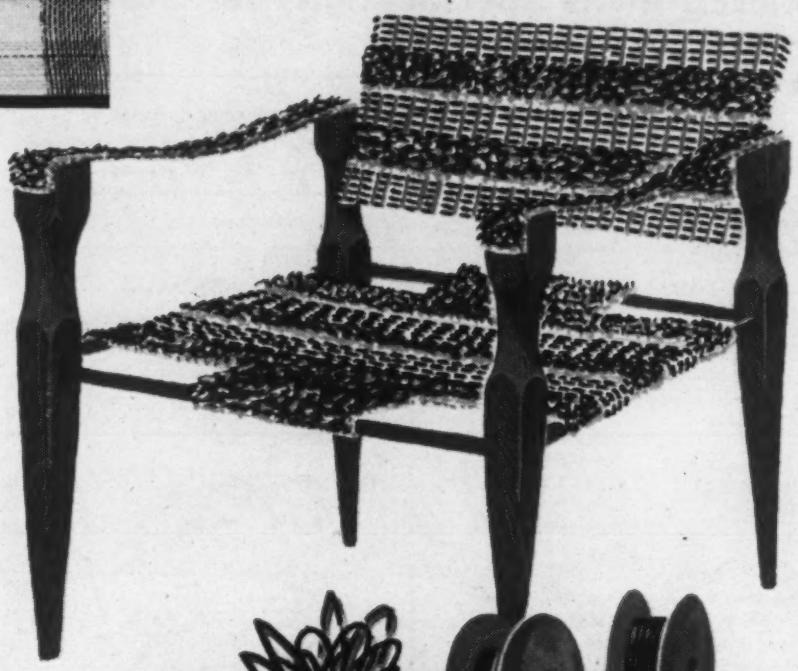

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Before *immersion in JP-4 jet fuel ordinary silicone (right) and nitrile silicone (left) look alike.*

During *immersion ordinary silicone curls out of shape whereas nitrile silicone keeps its shape.*

After *immersion ordinary silicone is distorted and swollen; nitrile silicone has about the same shape as before immersion.*

Nitrile Silicone — A New Rubber Resists Solvents, Is OK to 500 F

■ A new silicone rubber has resistance to common oils, fuels and solvents, and is useful in the temperature range from –100 F to over 500 F. The rubber, called nitrile silicone, is a product of General Electric Co., Silicone Products Dept., Waterford, N. Y. Charles E. Reed, general manager of the Silicone Products Dept., says the material will be commercially available before the end of this year.

Potential uses

Hoses, couplings, diaphragms, o-rings, seals and gaskets for use in aircraft, automobiles, railroad equipment, electrical devices and oil well equipment are some of the anticipated uses for nitrile silicone rubber. Specific applications include: aircraft fuel tank sealants; automobile power steering pump seals, crankshaft seals, brake parts and automatic transmission seals. Dr. Reed says the aircraft industry will probably be one of the primary users of the new material.

Properties and cost

GE's nitrile silicone rubber may replace fluorinated materials in some applications because it has three decided advantages over most of these materials: 1) it's cheaper, 2) it's easier to process, and 3) it has better mechanical and physical properties.

Dr. Reed says the fluorinated silicones have presented ". . . problems in processing and their applications have been limited by their relatively high cost." For instance, a currently available fluorinated silicone rubber sells for $22 to $27 per lb compared to an introductory price of $15 per

Molecular Structure

GE scientists describe the development of nitrile silicone rubber as follows: The organic parts of a typical silicone rubber are methyl groups that are attached to each silicon atom in the molecular structure of the rubber. These methyl groups are non-polar and are similar to those found in gasoline, naphtha and oils. Silicone rubber has an affinity for such fluids and swells when exposed to them. This affinity is greatly reduced by replacing some of the non-polar methyl groups with polar nitrile groups in the molecular structure of the rubber. The result: nitrile silicone rubber.

Basic research on the silicone rubber was done by Maurice Prober and Glenn D. Cooper of GE's Research Laboratory, Schenectady, N. Y. A practical method for making the rubber into a useful form before molding or extruding was developed by Ben A. Bluestein of the company's Silicone Products Dept. A pure nitrile intermediate is hydrolyzed, then polymerized, mixed with a filler and a vulcanizing agent, and heated in a mold. The material is then ready for molding or extruding.

***Extreme coldness** of dry ice does not affect flexibility of nitrile silicone rubber (top) whereas a fluorinated hydrocarbon rubber (bottom) becomes stiff and brittle.*

lb for GE's nitrile silicone rubber.

Nitrile silicone rubber is said to have better high and low temperature properties than most fluorinated hydrocarbon materials. Fluorinated hydrocarbon materials tend to soften and lose much of their physical strength at high temperatures.

GE's new silicone rubber is said to maintain good physical properties at temperatures from —100 F to 500 F, and to have low volume swell in JP-4 jet fuel, ASTM Reference Fuel A (iso-octane) and ASTM Reference Fuel B (iso-octane and toluene). It also has low volume swell in di-ester fluids (MIL-L-7808), ASTM No. 3 oil and Type A transmission fluid after aging 70 hr at 300 F.

The new silicone rubber is relatively easy to handle and can be processed on ordinary rubber fabricating equipment, according to GE.

May compete with Vitron

The closest competitive fluorinated material for nitrile silicone will probably be Du Pont's Viton (a linear copolymer of vinylidene fluoride and hexafluoropropylene). Viton sells for about $15 per lb for gum and by the time it is compounded and fabricated its price is about the same as that for compounded and fabricated nitrile silicone rubber. In other characteristics Viton and nitrile silicone rubber are about the same, except that nitrile silicone can be used at temperatures down to —100 F whereas Viton can only be used down to —40 F or —50 F. (For more information on Viton, see M/DE, May '58, p 166, and July '57, p 96.)

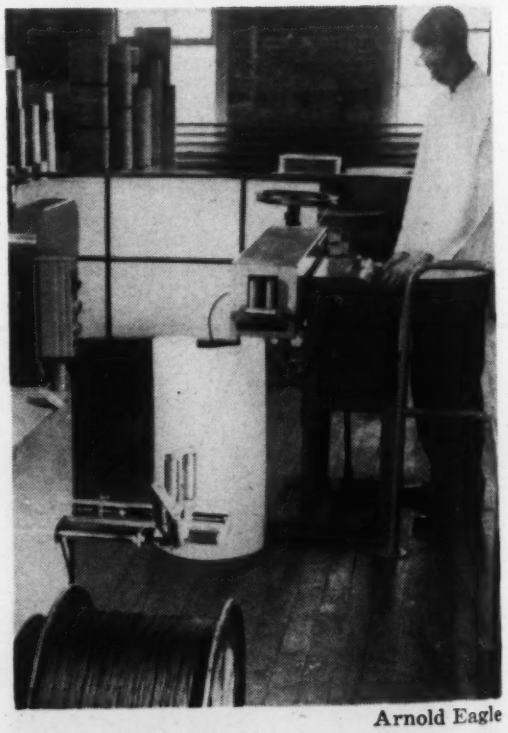
Thermoplastic Has Good Load-Bearing Properties

■ A copolymer of ethylene and other monomers, specific composition of which has not been revealed, has been developed by Celanese Corp. of America, 180 Madison Ave., New York 16. The thermoplastic material, called Fortiflex B, is the first of a group of tailor-made polyolefin resins designed for long-time sustained load-bearing service.

Biggest single use of the first polymer in the group will probably be monofilaments for such products as rope and outdoor furniture webbing. Commercial quantities of the polymer are now being produced at the company's Houston, Tex. plant. Other grades will soon be available for film, wire covering, pipe, blown bottles and paper covering.

Ralph H. Ball, technical director of the company's Plastics Div., says improved load-bearing properties are created in the new thermoplastic material by adding branches of the proper type at proper intervals to the long, straight molecular structure of rigid polyethylene. These branches, he says, substantially reduce any tendency of the molecules to slip past each other under stress.

A filament creep test was run on Fortiflex B and regular linear polyethylene samples under a dead load of about 25% of their tensile strength. The test shows that Fortiflex B elongates less than 10% and holds for 300 hr without rupture, whereas regular linear polyethylene elongates about 50% and ruptures in about 100 hr.



Arnold Eagle

***Wire coating** is a potential use for Celanese Corp.'s polyolefin resins.*

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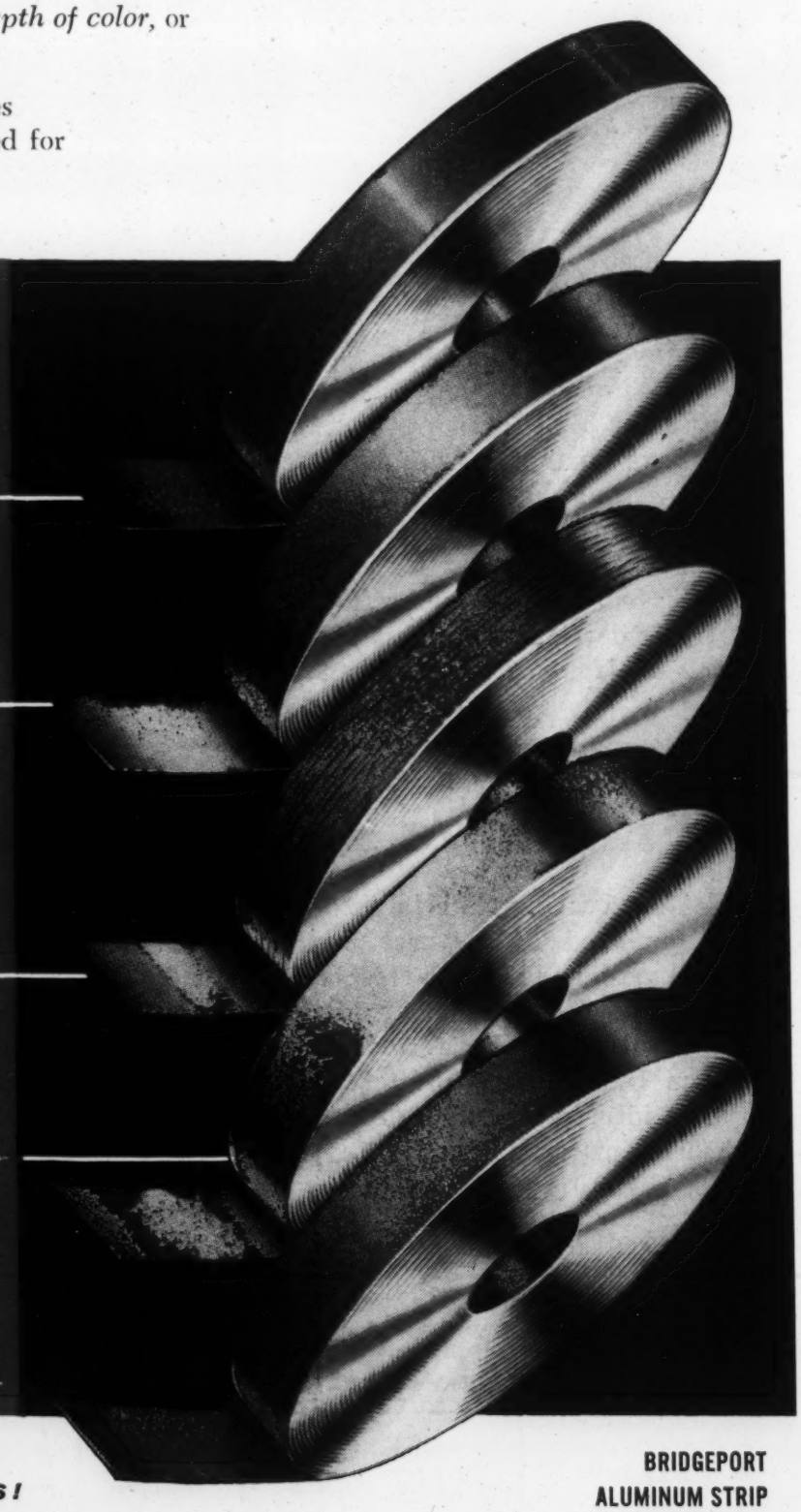
Bridgeport Pre-Painted Aluminum Strip not only insures an almost unlimited choice of colors, but provides a selection of *five distinct types of finishes.* Each finish offers an outstanding advantage or combination of advantages, such as *unmatched formability, maximum exterior durability, eye-catching beauty* and *depth of color,* or *unusually attractive metallic appearance.*

Bridgeport Pre-Painted Aluminum Strip actually reduces overall costs by eliminating painting, as well as the need for equipping and maintaining a finishing department.



GENERAL PURPOSE ENAMELED ALUMINUM STRIP—Maximum exterior durability, 2-coat baked enamel, hard, glossy surface withstands extreme exposure in all climates—coastal salt air, desert heat, high humidity, excessive moisture. Excellent formability without peeling, chipping or loss of adhesion. Available in an almost unlimited range of sun-fast colors.

HI-FORM ENAMELED ALUMINUM STRIP—For extreme deformation. A 2-coat baked enamel which stretches during formation to the limit of the metal's elongation! Thermo-setting vinyl enamel is so hard it's virtually scratchfree . . . proof against marring during handling. Gloss or satin finishes, all colors.

WOOD GRAIN ALUMINUM STRIP—A finish composed of a wood-colored, baked ground coat, a printed wood grain pattern followed by a baked, clear finish. Primarily recommended for interior applications but also available in scratch-proof, thermo-setting finish for exterior service. Low gloss; fade resistant; excellent formability; abrasion, moisture and detergent resistant. Choice of several color and grain variations.

HI-FORM EXTERIOR METALLIC FINISH ALUMINUM STRIP—Pastel tinted metallics. Soft colors blend harmoniously with surroundings. Extreme formability with all other desirable properties . . . sun-fast colors, good exterior durability in all climates.

HI-FORM INTERIOR METALLIC FINISH ALUMINUM STRIP—A series of schematic, realistic metallics in brass, bronze and copper shades. 2-coat finish consists of a primer containing ultra-fine metallic particles protected with clear top coat. Excellent moisture and detergent resistance. Excellent formability, good abrasion resistance. Bright or satin finish. For decorative interior applications.

ASK YOUR BRIDGEPORT SALESMAN FOR MORE INFORMATION AND SAMPLES!

He will gladly obtain our factory recommendations showing how you can save money on present production, improve existing products or adapt this material to new uses with imagination and maximum resulting sales appeal.

BRIDGEPORT ALUMINUM STRIP also available in PLAIN and MILL FINISHES

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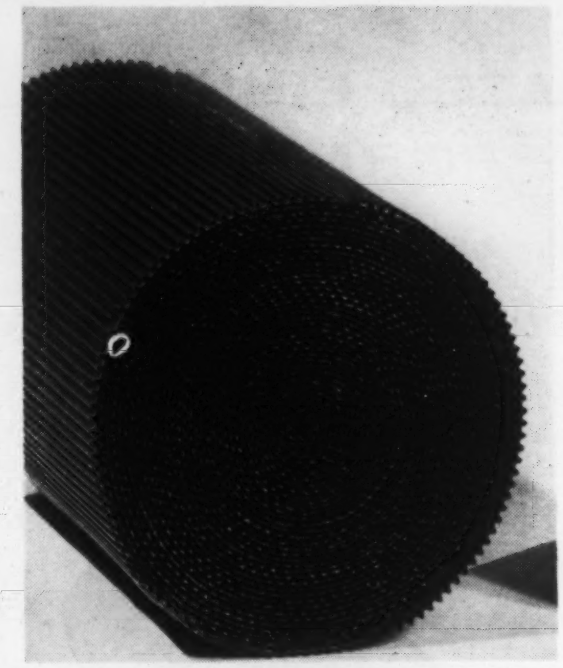
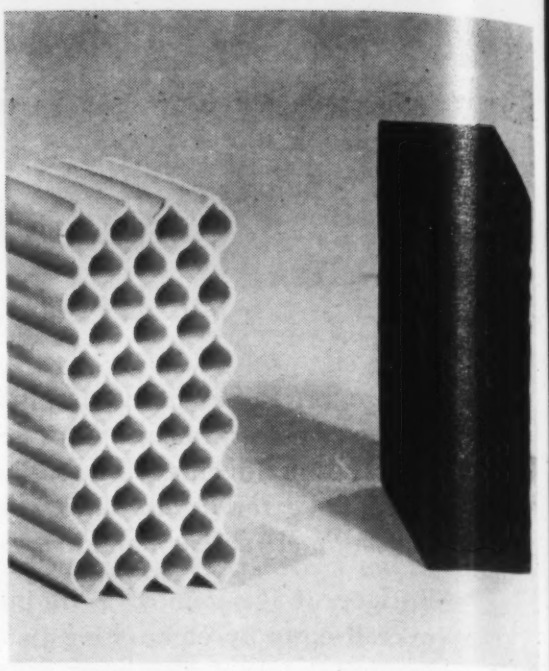
Bridgeport Brass Company, Sales Offices in Principal Cities

For more information, turn to Reader Service card, circle No. 491



Continuous corrugated shape *of magnesium aluminum silicate has 20 corrugations per inch and is approx 0.002 in. thick. Potential uses: heat exchangers and parts for automobile exhaust systems.*



***Honeycomb* shape** *of zirconium oxide (left) has 3 corrugations per inch and is approx 0.020 in. thick. Similar shape of bonded silicon carbide (right) has 7 corrugations per inch and is approx 0.005 in. thick. Potential uses: high temperature, lightweight structures in aircraft and missiles. The company says similar shapes have been made for nuclear reactor fuel elements.*

Ceramic Shapes Now Offer High Surface Area

■ Any ceramic material can be made into very thin corrugated or other high surface area structures by using a newly developed fabricating technique. Ceramic shapes turned out by the process are said to be suited for extreme high temperature applications.

The developer, Minnesota Mining & Mfg. Co., has not revealed complete details of the fabricating technique, but it does say the technique permits rolling and forming ceramics much as metals are rolled and formed. Though ductile during fabrication, the ceramic shapes are no longer ductile after fabrication.

The technique permits for the first time, 3M says, the fabrication of ceramic heat exchanger units, catalyst supports and lightweight structural units—constructions which heretofore could be made only of metals.

The ceramic shapes are in limited production at American Lava Corp. (a 3M subsidiary), Cherokee Blvd. & Manufacturers Rd., Chattanooga 5, Tenn.

TFE-Bronze Bearing Material

■ A dry bearing material incorporating filled TFE, woven bronze wire mesh and a plated steel backing is now commercially available in a variety of shapes and forms from Dixon Corp., Bristol, R. I. (For information on another dry bearing material, see M/DE, Sept '58, p 150.)

This article is based on a paper by Robert Rulon Miller, Dixon Corp., and Sidney Low and Saul Ricklin, consultants for Dixon Corp.

According to the producer, bearings made of the material, designated Rulon S-Liner, have been run continuously without lubrication for over 1000 hr at PV values of 20,000 and intermittently at PV values of 40,000. These values compare with PV ratings of 3000 to 5000 for filled TFE, 500 to 2000 for nylon, and 1000 for unfilled TFE under similar conditions.

(continued on p 144)

BEARING CHARACTERISTICS OF RULON S-LINER

PV[a]	Load, psi	Running Time, hr	Total Wear, in.	Temp Rise, °F	Bearing Condition
30,000	135	250	0.009	275	Worn through
25,000	121	850	0.009	275	Worn through
20,000	97	1215	0.008	125	Worn through
15,000	72	2130	0.003	90	Still running
5,000	24	1954	0.0025	45	Still running

[a] Load per sq in. of bearing area times velocity in fpm.

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Write today, please mention your cut part end use or include blueprint, for further information and quotations. For even *faster* service, call your local American Felt Company Office.

Remember: American Felt Company has the most extensive and best equipped staff of product engineers in the Felt Industry with *engineered* materials for seals, wicks, filters, insulation, decoration. Write for information, please describe your application...

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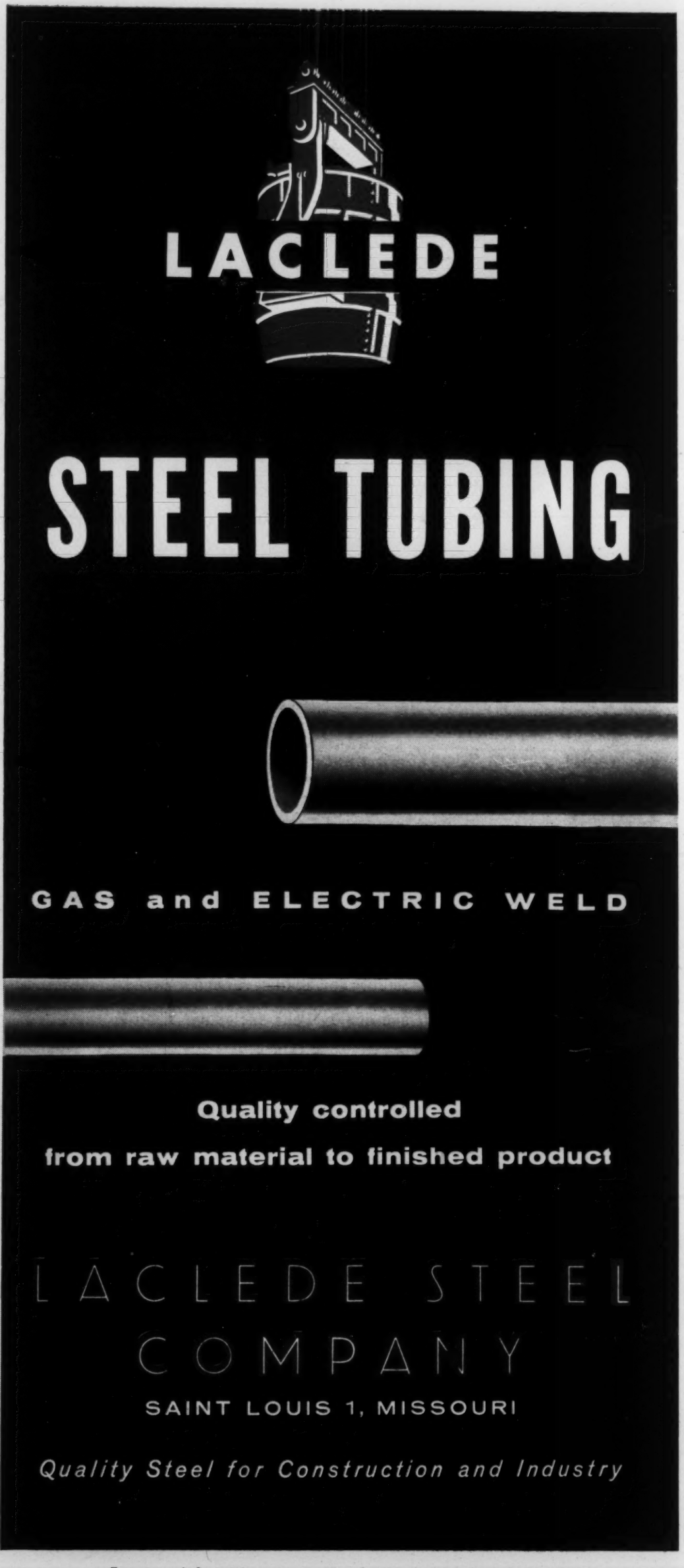


Applications

Sleeve bearings will probably be the biggest single use for the new material, according to Dixon. Rulon S-Liner sleeve bearings can operate at both high and low temperatures and in corrosive atmospheres. In addition to sleeve bearings, the material is expected to be used for guides, slides, washers, gaskets, seals and packings.

A typical application for the material is a bearing in a stirrer that is completely submerged in oleic and stearic acids, and in ethylene oxide at 375 F. In this application the TFE-bronze bearing has successfully performed for 2700 hr at 130 rpm with no sign of failure. Ball bearings costing approximately $300 each were formerly used in the stirrer.

Properties

Wear resistance: A Rulon S-Liner bearing ½ in. in dia and ¼ in. long was mounted on a steel shaft, loaded with weights to give various PV values, and run continuously at 1725 rpm without any lubrication. Test results are shown in an accompanying table.

They indicate that bearing life is limited to about 1500 hr at a PV value of 20,000 and to several thousand hours at PV values of 15,000 or lower. When run intermittently, at 40,000 PV, the bearing was still in good condition after 800 hr.

The TFE-bronze bearing material is said to give excellent service when run as a lubricated bearing. In one test, 4000 hr of operation were obtained at a PV value of 60,000 without any sign of bearing deterioration.

Heat resistance: Although Rulon S-Liner bearings are capable of operating at temperatures from –400 F to 550 F, care should be taken when using the material at high temperatures.

Coefficient of friction: The bearing material has a coefficient of friction of 0.15 to 0.20—about the same as for TFE.

Availability

The bearing material is available as standard rolled sleeve bearings and as sheet and strip in sizes up to 6 x 12 in. The sheet can be cut and formed into half rounds, thrust washers and flanged pieces.

The TFE-bronze bearing material

For more information, turn to Reader Service Card, circle No. 393

Trevarno makes it you think tougher than

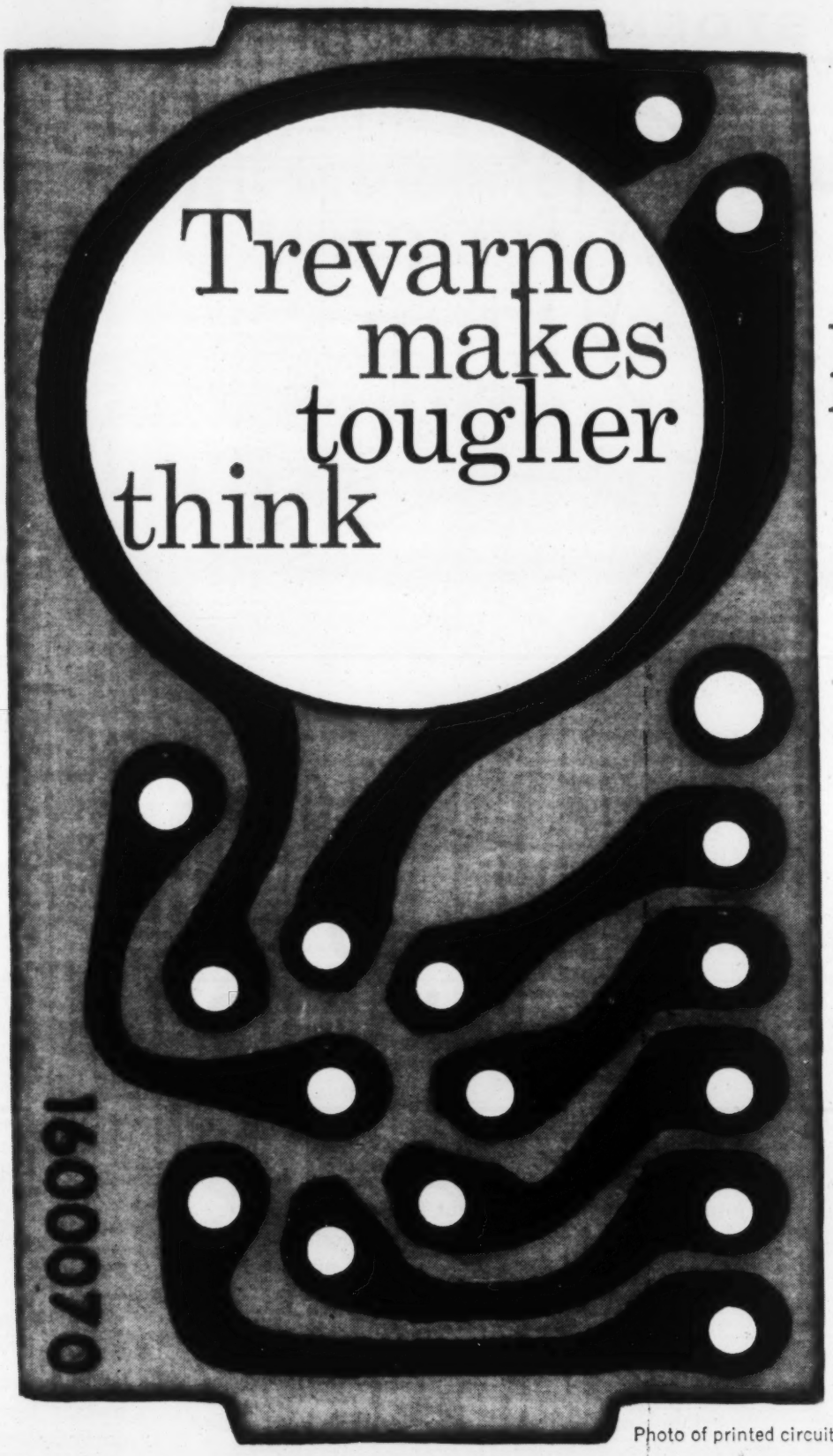
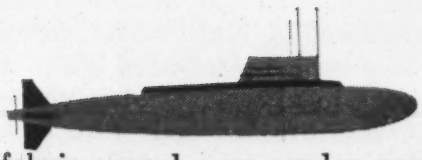


Photo of printed circuit—four times actual size



This sound amplifying circuit, printed on Trevarno resin impregnated glass fabric, speaks up under conditions tougher than you can imagine. It operates at peak efficiency under the most severe conditions of vibration, heat and humidity in Navy submarines. That's why it must have tough insulating backing that won't shrink, swell or bend; resists temperatures of more than 500° F. Laminated of Trevarno epoxy impregnated glass fabric by the Mica Corporation, "Micaply" backs up printed circuitry produced by Etching Company of California for military craft both in the air and under the sea. If you want to make a product better Trevarno's staff of experts is ready to help you develop new or special materials meeting the most exacting specifications. Write Coast Manufacturing & Supply Company, P.O. Box 71, Livermore, California. Sales offices: 4924 Greenville Avenue, Dallas, Texas; 635 South Kenmore Avenue, Los Angeles, California; 114 North Main Street, South Bend, Indiana. Plants at Livermore, California and Seguin, Texas.

Trevarno
GLASS FABRICS

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No. 3 of a Series

GRIPPING STORIES
from the files of Angier Adhesives

The Case of the BAFFLED DESIGNER

It was a tough job and "Rush", but now he had it licked. All he needed was the adhesive that would join the rubber component to the metal base. "No problem here," he thought, as he specified the rubber-to-metal formula that had been so successful in a previous job.

But there *was* a problem and it became more and more apparent as one after another of the trial bondings failed.

Once on the case, an Angier man unravelled the mystery in short order. He pointed out slight–*but important*–differences between the old product and the new–in rubber compound used, in end-product vibration and in heat and stress factors involved. He recommended an adhesive that was perfect in every respect and the designer met his deadline with two days to spare.

Turn to Angier *first* for job-tailored adhesives that are developed, tested and produced *by experts* to give you the most efficient product for every job at the lowest price per end-product unit.

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What's new IN MATERIALS

is also available without a steel backing. Designated Rulon Slip-Liner, it can be bonded to other materials by using solders or adhesives. The flexible Slip-Liner can be formed into grooved or flanged shapes.

Copper Best Material for Buried Pipes, Tanks

Copper seems to be the best material to use for pipes, cables, tanks and other structures that are to be buried under soil, according to a recent report from the National Bureau of Standards. The report, No. 2209, summarizes 45 years of work by the Bureau in evaluating the corrosion resistance of ferrous and nonferrous metals and coatings buried underground.

In the Bureau's prolonged field burial program, data were obtained on nearly 37,000 specimens representing 330 varieties of materials. The specimens were exposed for periods up to 17 years in 95 types of soil. The soils varied from soft peats, clays, loams and silts to coarse sands and gravels. Exhumed specimens were treated in the laboratory to remove corrosion products, then measured for weight loss and pit depth.

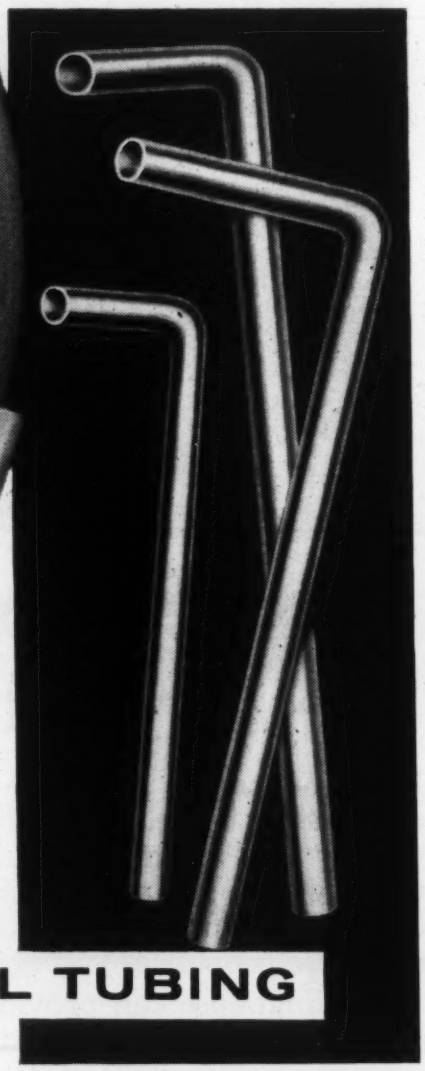
How materials rate

Plain ferrous metals corroded much more rapidly than all other metals tested, except for zinc which corroded more than steel in a high sulfate soil. Unalloyed irons and steels showed a high initial corrosion rate which decreased after a few years to almost complete cessation in well drained soils with high resistivities. Corrosion rate in poorly drained soils with low resistivities was nearly constant after the first year or two.

Alloy steels and irons were more resistant to corrosion than plain ferrous metals. The alloying ele-

WATCH FOR 'SELECTOR'—The second edition of M/DE's *Materials Selector*—revised, expanded and updated—will be published later this month. The special issue is included in the M/DE subscription.

When it's time to talk **tubing**...



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ments chromium and molybdenum were particularly effective in reducing the corrosion of low alloy steels in the most corrosive site, a cinder fill. Austenitic cast iron was considerably more resistant to corrosion than plain cast iron.

Copper and copper alloys showed the highest corrosion resistance of all metals tested. Soils, including cinders, with high concentrations of sulfides and chlorides were the most corrosive toward copper.

Lead showed good corrosion resistance to soils high in sulfates, chlorides and carbonates.

Galvanized coatings afforded protection to iron and steel according to the type of soil in which they were exposed. Inorganic oxidizing soils required a 2-oz-per-sq-ft coating of zinc for sufficient protection,

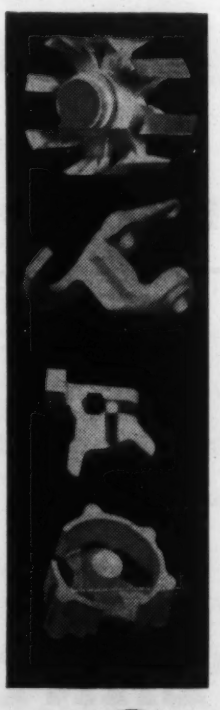
This part cast from a magnetic alloy, Hipernik®, cut production costs 80%.

CUT COSTS WITH INVESTMENT CASTING OF MAGNETIC ALLOYS

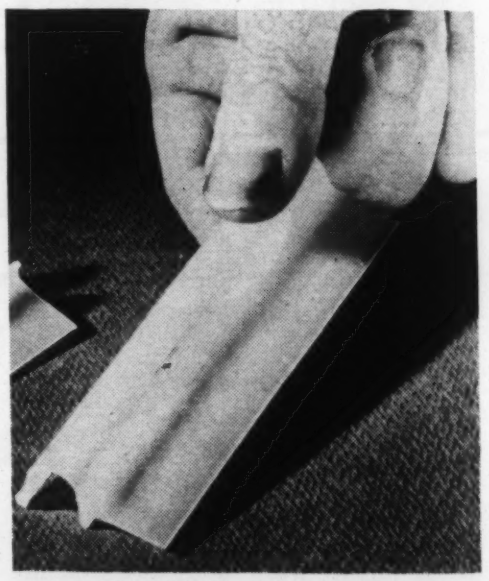
Many of today's alloys are difficult or impossible to machine or forge. Many magnetic parts and components are so intricate in shape that to machine them would require multiple set-ups. Investment casting minimizes machining costs, yet retains the magnetic properties you need.

Westinghouse can provide castings of high-nickel magnetic alloys that retain comparable magnetic properties of wrought materials. With value and cost analysis so important, consider precision investment casting of your magnetic product components.

Whether you need small quantities of prototype parts or production runs, the Westinghouse Metals Plant has the complete metal facilities and experienced engineers to help improve cost and quality of your component parts. For further details on Investment Castings, ask for DB-52-500. Write Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pa. J-05006



YOU CAN BE SURE...IF IT'S Westinghouse



Nylon for large extrusions—This nylon extrusion is made of a high melt viscosity material called Plaskon 8205. Developed especially for the extrusion of large shapes, the compound is available from Plastics and Coal Chemicals Div., Allied Chemical Corp., 40 Rector St., New York 6. Barrett says the nylon compound can be extruded at temperatures ranging from 450 to 550 F into structural shapes, tubing, pipe, tape, rods and film. The compound is also suited for blow molding of bottles and containers. Molded Plaskon 8205 has an ultimate tensile strength of 12,000 psi, a flexural strength of 14,000 psi, a Rockwell R hardness of 118, and a specific gravity of 1.13.

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because of its lightweight and smooth wearing qualities.

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Chemloy 719

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. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p or specs. for quotation on molded or machined parts.

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CRANE PACKING COMPANY

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What's new IN MATERIALS

whereas inorganic reducing soils required a 3-oz-per-sq-ft coating.

Porcelain enamel coatings showed no signs of deterioration after 14 years of exposure.

Baked phenolic coatings showed marked superiority to air dried phenolic coatings in preventing pit formation in the underlying steel.

Phenolic Resin for Missile, Rocket Parts

A phenolic resin especially formulated for missile and rocket parts was announced recently by Reichhold Chemicals, Inc., Plastics Div., White Plains, N. Y. The company says laminates made from the resin will withstand temperatures up to 4500 F for brief periods, and temperatures up to 500 F for 100 hr and longer.

The resin, designated Plyophen 5900, is said to produce laminates having high strength at elevated temperatures; low moisture absorption; good insulation properties; and good resistance to organic solvents, weak inorganic acids, hydraulic fluids and hot gas erosion.

Laminates made from the resin have an ultimate flexural strength (flatwise) of 85,900 psi and a compressive strength (edgewise) of 60,240 psi at room temperature. The laminates retain a flexural strength of 67,320 psi after aging 100 hr at 500 F. (For information on other plastics for missile and rocket parts, see M/DE, June '58, p 100.)

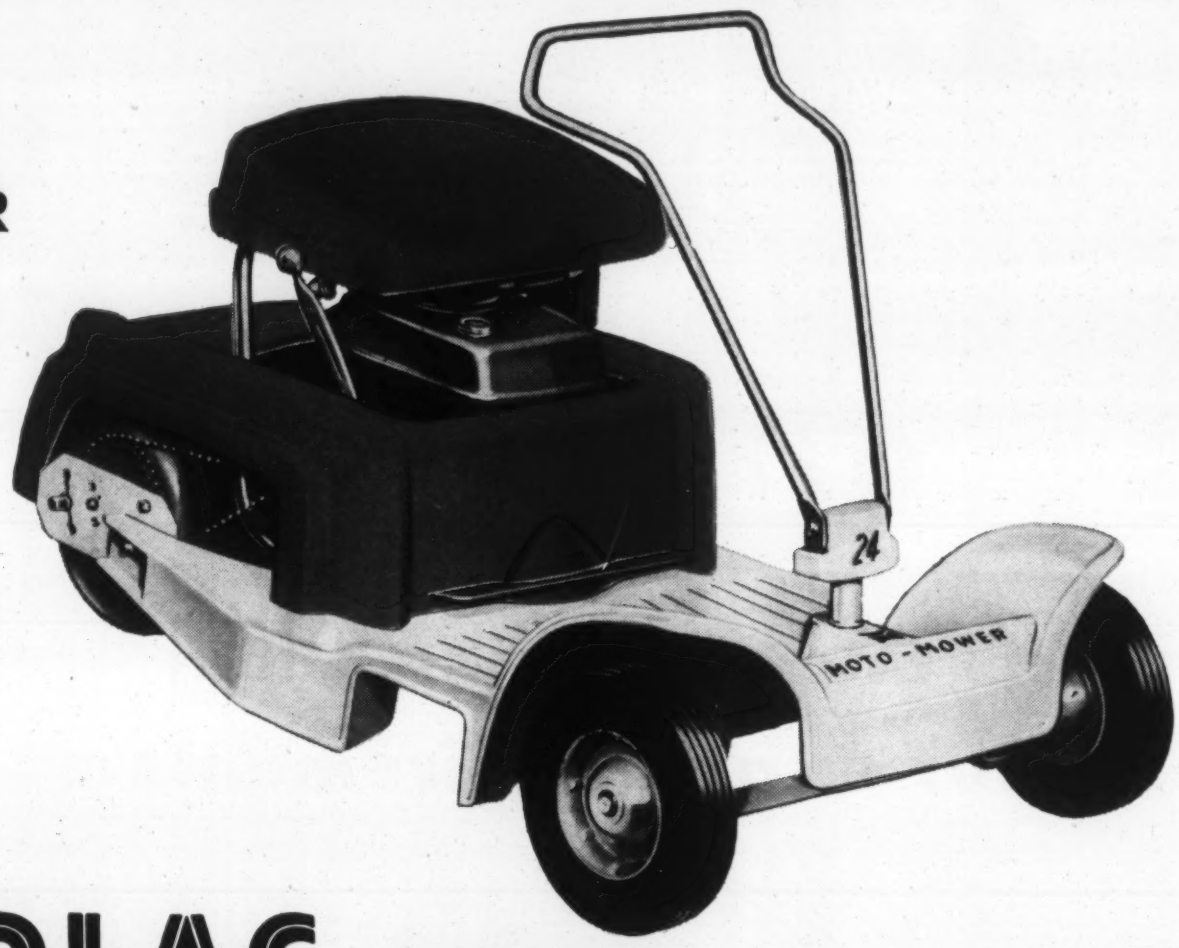
Glass-Coated Steel Resists Thermal Shock

An improved glass-coated steel with 30% greater resistance to thermal shock than a previous product has been introduced by Pfaudler Co., Div. of Pfaudler Permutit Inc., 1072 West Ave., Rochester 11, N. Y. Tests show that the material, called Glasteel 59, can be heated to 450 F and quenched in cold water without damage. Other glass-coated steels exhibited excessive crazing when tested under the same conditions.

For greater selling impact

MOTO-MOWER

FORMS SEAT and SHROUD



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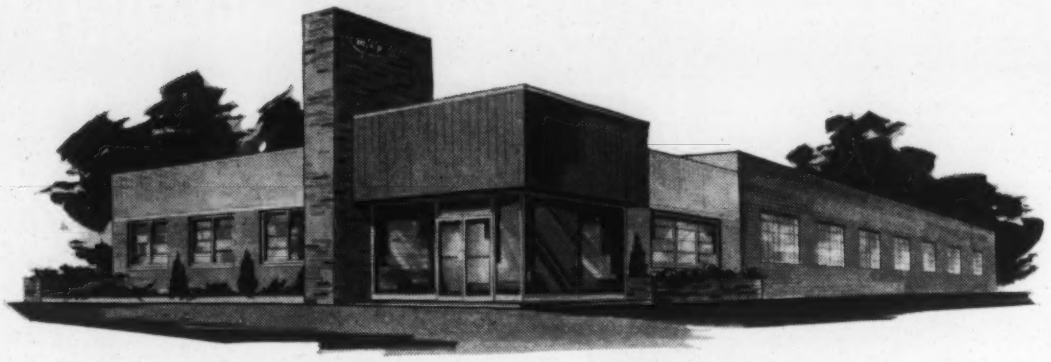
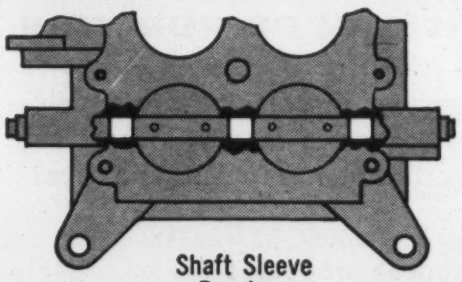


mip

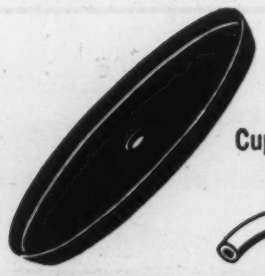
molds and machines Teflon® to your exact requirements

Ring Seals and Piston Rings

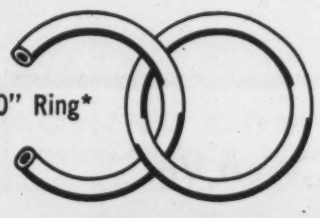
Riload Sleeve Bearing*



Shaft Sleeve Bearings



Cup Seals



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assures effective evaluation of designs and production parts that will DO THE JOB for you. MIP fabricates fluorocarbon plastics exclusively.

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No possibility is overlooked in selecting the right combination of materials, design and manufacturing methods to yield the utmost in finished product performance and economy.

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MODERN INDUSTRIAL PLASTICS, INC.

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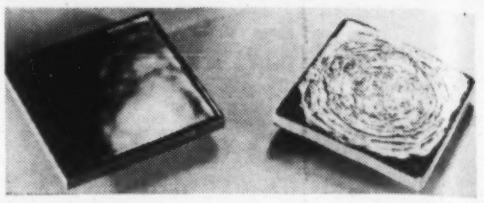


***No cracks** appear in Glasteel 59 (left) after quenching in cold water from 450 F. Previous glass-coated steel (right) cracked under these conditions.*

The glass-coated steel is said to resist attack by all acids except hydrofluoric. The company says the material can be used with acids at temperatures up to 325 F without corrosion damage, and at temperatures as high at 450 F under certain conditions.

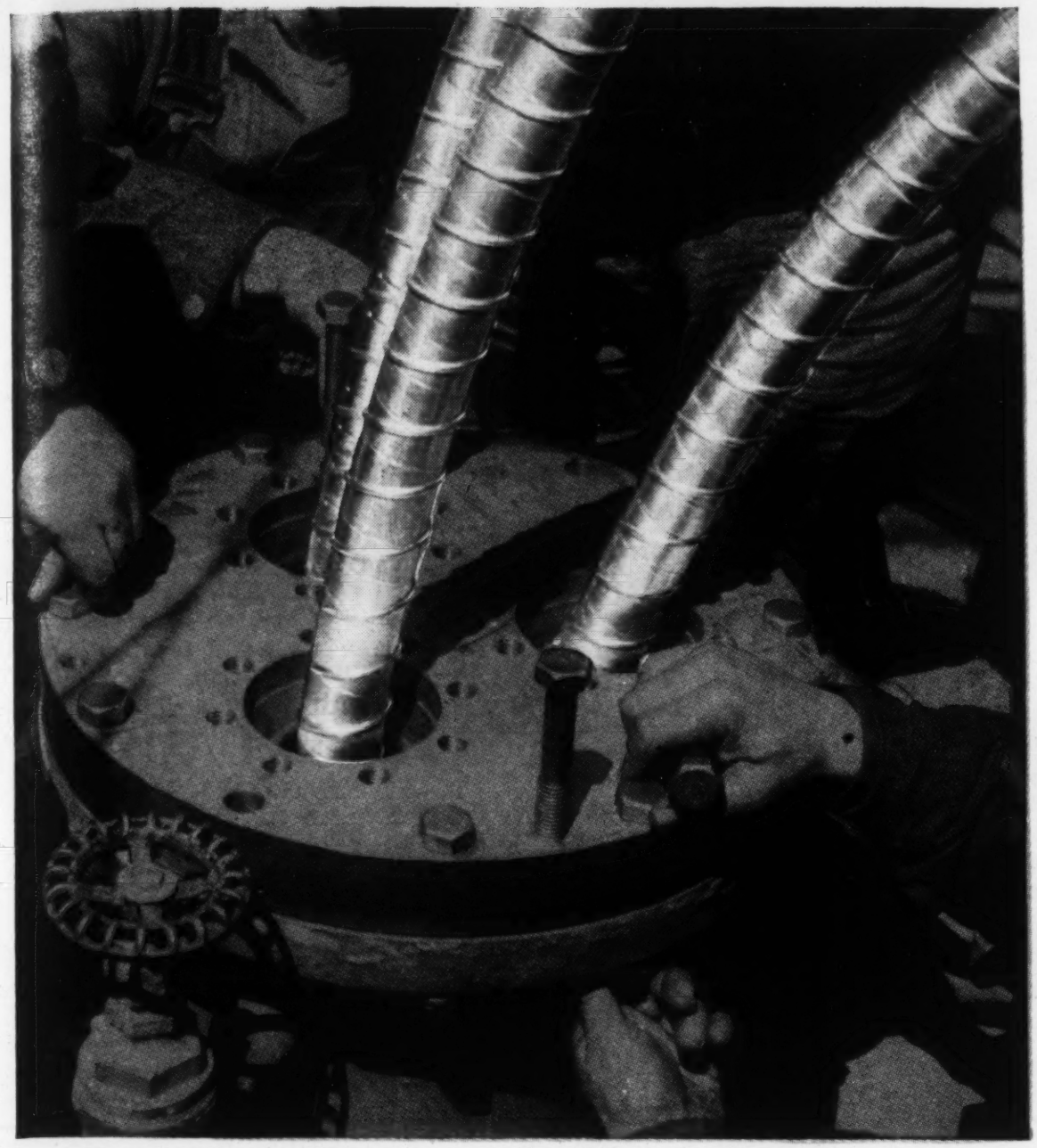
Biggest single use for the glass-coated steel will probably be chemical process equipment.

New Silicone Improves Properties of Paints

A new silicone resin has been developed by Silicones Div., Union Carbide Corp. to improve the color and gloss retention, thermal stability and weather resistance of alkyd, melamine and acrylic baking enamels. Called R-64, the silicone resin has a solids content of 65%, a viscosity of 15 to 50 centistokes, a flash point of 50 F, and a specific gravity of 1.08. The resin is expected to find use as a base for aluminum paints that operate in the 500 to 1200 F range.

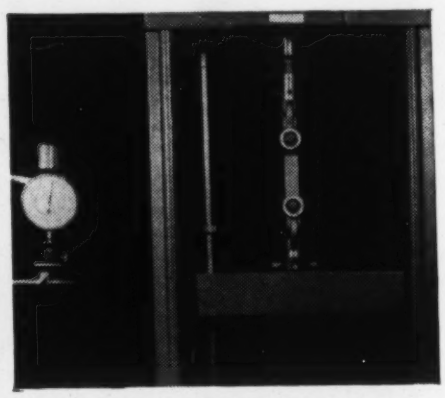
Premixed Compounds Produce Rigid Foams

Two urethane foam formulations, premixed in a two-part package, have been developed by Allied Chemical Corp., Plastics & Coal Chemicals Div., 40 Rector St., New York 6 to eliminate costly errors in the mixing of urethane foam formulations. The producer says maximum uniformity of foam cell structure and equal density of batches is insured because all the necessary ingredients are

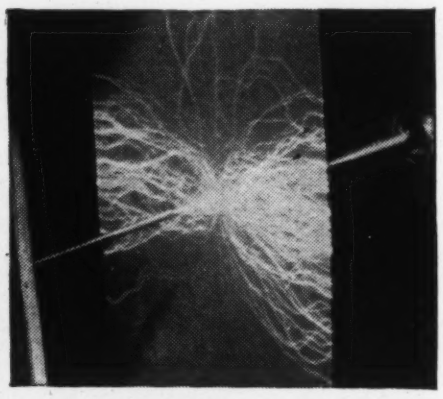


PROPERTIES OF "MYLAR"

"Mylar" offers a unique combination of properties that may help you improve performance and lower costs of *your* product. Here are two of the many important properties for evaluation.



HIGH TENSILE STRENGTH. "Mylar' is strong and durable. Instron Tester shows an average strength of 20,000 psi. It's dimensionally stable . . . resists moisture.



HIGH DIELECTRIC STRENGTH. Average of 4,000 volts per mil . . . average power factor of 0.003 to 60 cycles .

General Cable reports . . .

New shielding assembly with Du Pont Mylar® limits oil drainage . . . restricts moisture pickup

PROBLEM: To provide an outer shielding assembly on General Cable's high-voltage, high-pressure pipe-type cable. The assembly had to resist oil drainage during shipment and storage as well as restrict surface-moisture pickup during installation.

SOLUTION: After extensive tests on various materials, General Cable Corporation adopted two new tapes for the outer shielding assembly . . . one tape was "Mylar"* polyester film; and the other, a "Mylar"/foil lamination.

RESULTS: General Cable tests showed that "Mylar" provided a tight, yet flexible, assembly and effectively reduced oil drainage. The high tensile strength and other excellent physical properties of "Mylar" permit its application to the cable under high tension. "Mylar" restricts surface-moisture pickup when the cable is exposed to air during installation. "Mylar" is not affected by the insulating oils . . . has no plasticizer . . . will not contaminate other materials.

How can "Mylar" help you? Whether you manufacture heavy-duty cable or tiny capacitors, it will pay you to evaluate the combination of properties found only in "Mylar." And when figured on an area basis, this tough, thin polyester film will often *cost less* than your present insulating material. For more detailed information, send in coupon.

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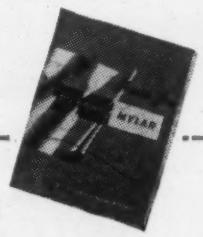
. . . THROUGH CHEMISTRY

DU PONT **MYLAR**® POLYESTER FILM

*"MYLAR" *is Du Pont's registered trademark for its brand of polyester film.*



E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room MM-10, Nemours Bldg., Wilmington 98, Del.
Please send the new booklet listing properties, applications and types of "Mylar" polyester film available (MB-11).

Application _____

Name _____ **Title** _____

Company _____

Address _____

City _____ **State** _____

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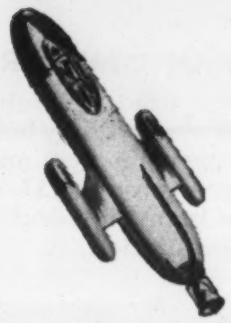
VISIT BOOTH 306,
at the Metals Show,
Cleveland, Ohio



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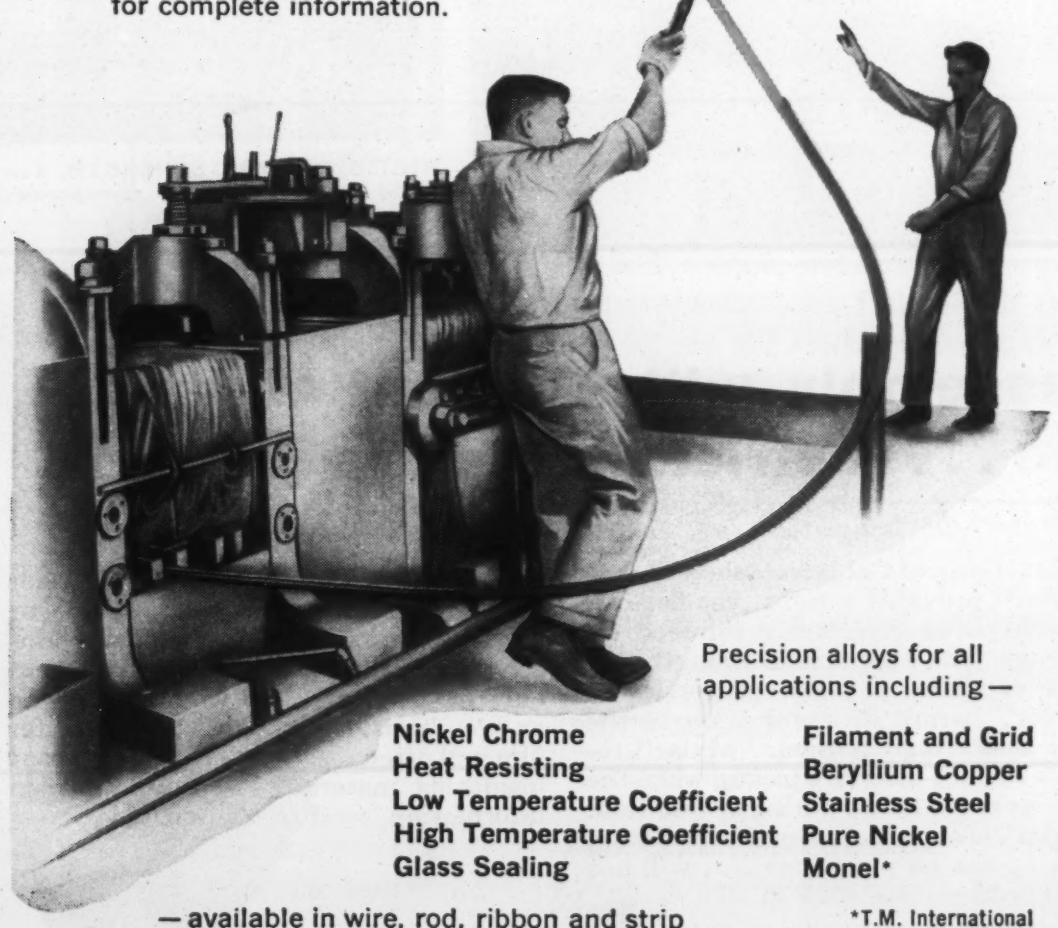
In addition to the complete line of precision resistance, chemical and mechanical alloys, Wilbur B. Driver produces alloys for special purposes. These custom alloys, vacuum melted and processed into wire or strip, solve critical production problems. This new service provides industry with complete engineering and production facilities and features one of the nation's largest vacuum-melting installations. Ask our Sales Engineering Department for complete information.



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Nickel Chrome	Filament and Grid
Heat Resisting	Beryllium Copper
Low Temperature Coefficient	Stainless Steel
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—available in wire, rod, ribbon and strip

—with insulations of enamel, Formvar, liquid Nylon, cotton, silk, Nylon and fibre glass

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What's new IN MATERIALS

accurately pre-measured into the two drums.

One foam formulation, Plaskon PFR 500, is specially formulated to produce maximum dimensional stability when subjected to high temperatures and high humidity. It is suitable for continuous service at 250 F and intermittent service at 300 F.

The other formulation, PFR 501, is formulated to produce minimum density foams for use as low cost void fillers and in flotation applications such as watertight chambers. PFR 501 is not designed for high temperature applications.

Metallized Glass Fiber Is Lightweight, Tough

Metallized glass fibers are said to be so light they float in ordinary air currents, yet so tough (when formed into thin mats) they can resist the impact from a projectile. The fibers were developed by Commonwealth Engineering Co., 1771 Springfield St., Dayton 3, Ohio.

The new material is made by subjecting glass fibers to a special gas plating technique wherein nickel, chromium, copper and other metals are applied in a continuous operation. The company says the process is being made available for license.

Potential uses for the metallized fibers include missile parts and decorative household products.

Soft Silicone Rubbers for Missiles, Aircraft

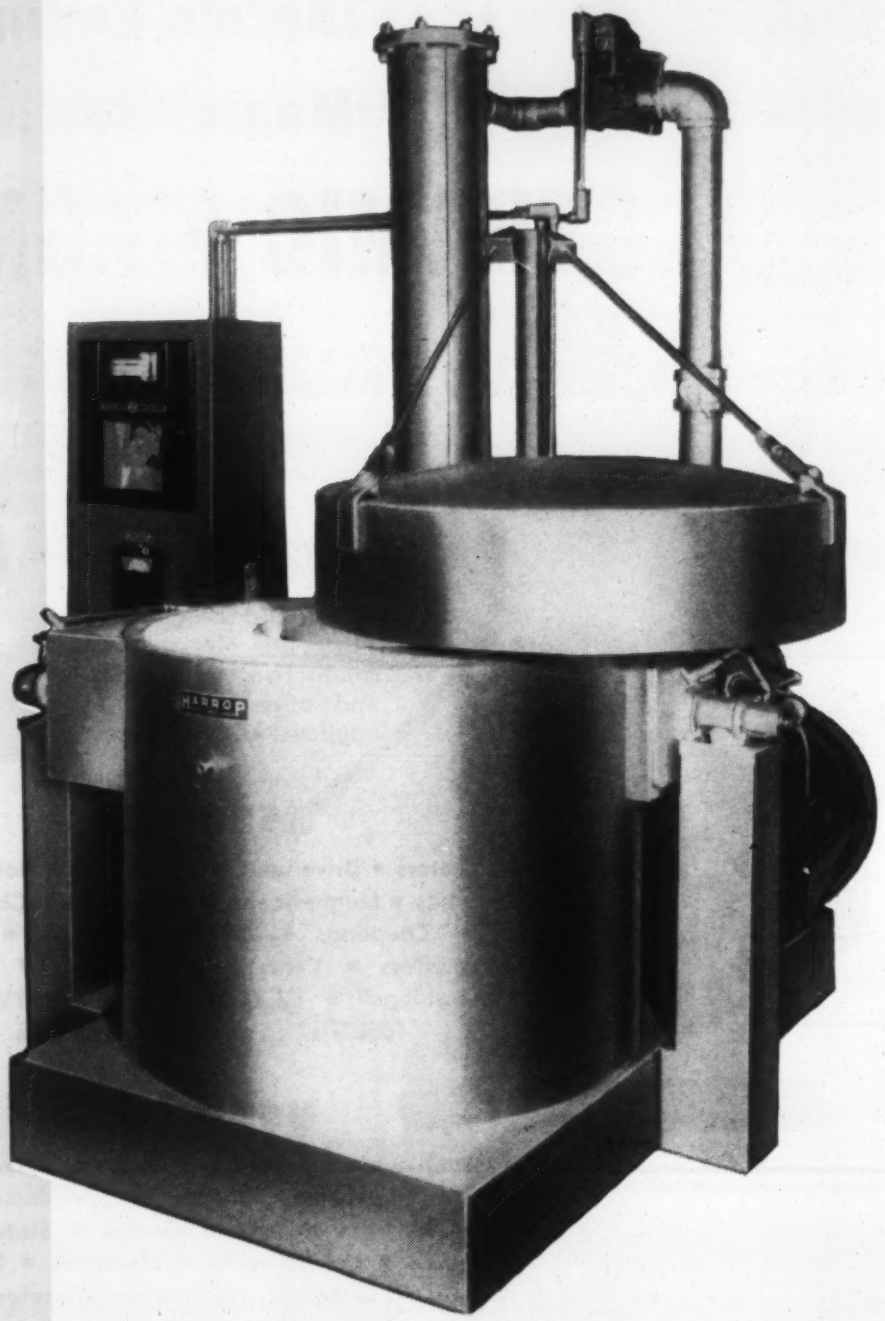
Two new silicone rubber compounds especially suited for aircraft and missiles are available from General Electric Co., Silicone Products Dept., Waterford, N. Y.

SE-525 is a 25 durometer compound having a tensile strength of 1000 psi, an elongation of 700% and a tear strength of 100 lb per in. Potential uses include molded and extruded seals, low pressure gaskets, cushions and other aircraft parts.

SE-567 is a 60 durometer compound with good flame resistance. Potential uses include airframe seals

New Protection For YOUR Equipment— At Temperatures Up To 3300°F

ALUNDUM castables offer unusual advantages to all industries using high temperature installations*



Will fire continuously up to 3300°F. This Harrop gas-fired furnace, recently developed by the Electric Furnace Division of the Harrop Ceramic Service Company, Columbus, Ohio, is particularly applicable to the firing of ceramic oxide bodies. Norton ALUNDUM 33-I Insulating Castable selected for the inner lining of the furnace and its roof, provided completely satisfactory protection under repeated tests at highest operating temperatures.

The new Norton ALUNDUM Castables are made in two types: 33-I Insulating and 33-HD Heavy Duty. At temperatures up to 3300°F both types have been extremely successful in protecting high temperature processing — in many industries and many different installations.

ALUNDUM 33-I Insulating Castable is made up primarily of pure aluminum oxide bubbles, tiny and countless. Forming a network of air spaces, it assures excellent insulation, even at highest commercial temperatures.

ALUNDUM 33-HD Heavy Duty Castable is chiefly composed of dense grains of pure aluminum oxide. It is recommended for forming dense monolithic surfaces in many types of furnaces where high temperature conditions are particularly severe.

Both 33-I and 33-HD Castables are very easy to store, mix and use. With them you can cast simple or complex shapes quickly and economically, replace more expensive pre-fired shapes, and cut maintenance and replacement costs to very lowest. Ask your Norton Representative for details, and for the folder *Two Norton Castables.* Or write to NORTON COMPANY, Refractories Division, 349 New Bond Street, Worcester 6, Massachusetts.

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NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — **BEHR-MANNING DIVISION** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

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You can do things with Stackpole Ceramagnet you can't do with conventional permanent magnets . . . and you can handle many ordinary magnet applications better . . . often at less cost. Ceramic magnets have highest magnetic permanency. No keepers needed. They are electrically nonconductive, weigh less . . . and offer numerous other application advantages.

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WRITE FOR ENGINEERING BULLETIN RC-11A

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St. Marys, Pa.

STACKPOLE *Ceramagnet*®

THE PERMANENT MAGNETS THAT ARE REALLY PERMANENT

For more information, turn to Reader Service card, circle No. 435

What's new IN MATERIALS

and jacketing for wires and cables.

Both compounds are said to have excellent handling characteristics and may be molded and extruded by standard techniques.

Plastics Riveted by New Technique

by Anthony Rufolo*

A method for riveting plastics laminates to themselves and to other materials shows promise as a relatively high speed fastening method for a variety of plastics parts. The method, still in the experimental stage, uses a conventional pneumatic riveting gun in conjunction with a specially shaped steel dolly. Developed by researchers in the Materials Laboratory of the New York Naval Shipyard, Brooklyn, N. Y., the technique uses aluminum rivets.

Two-step operation

After extensive laboratory investigation we developed a two-step riveting method in which the point of the rivet is 1) flattened to approximately half its length, and 2) secured against the surface of the laminate by a special rolling technique.

We had to rule out the conventional one-step operation because the riveting gun damaged the plastics laminate. In addition, hot steel rivets used in the one-step operation could not be used as they burned and scorched the laminate. As a result our study was restricted to cold aluminum rivets. We also had to use low forming loads because high loads damaged the plastics laminate. These were not severe restrictions since aluminum rivets have relatively high strengths, and low forming loads are permitted when designing structural plastics parts.

How method works

A conventional riveting gun delivering 1680 blows per min and operating at 90 psi air pressure was used to drive aluminum rivets into test samples of glass cloth and glass-mat-polyester laminates. The procedure is as follows:

1. A riveting gun containing a

*The author is associated with the New York Naval Shipyard.

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You can avoid costly production delays due to irregular grain size, temper, color, wall thickness and O.D. by specifying parts and tubing by H & H. Remember that H & H, by its use of a modern electric annealing furnace, by constantly applying the most stringent laboratory controls, by its careful in-process inspection of tubing sizes, gives meaning to the words "planned for precision". They are your guarantee of tubing *exactly* as you want it.

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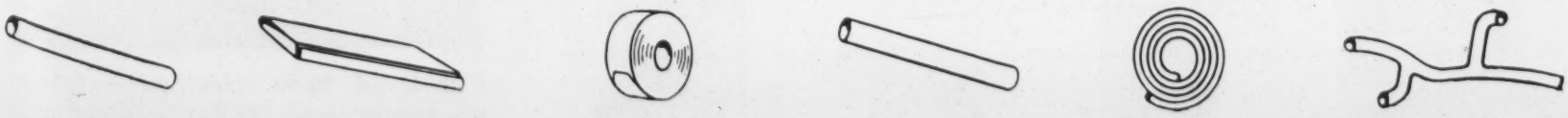

METALFLO LOCKSEAM COIL STRIP SEAMLESS TUBING TUBULAR PARTS

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New Star Performer In The Sandvik Line

SANDVIK

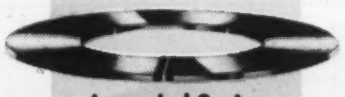
Presents A SUPER SPRING STEEL

Sandvik's new 2R25 is a superior grade of stainless spring steel which goes far beyond the capabilities of ordinary spring steels. It was developed for applications where performance outranks cost.

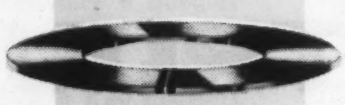
This new steel is a prime example of Sandvik's ability to combine several advantageous properties in one metal. *Sandvik 2R25 is exceptionally tough and resilient, much more formable than hardened and tempered steel, has up to 10 times the fatigue life of ordinary carbon spring steel and has excellent corrosion resistance under varying atmospheric conditions.*

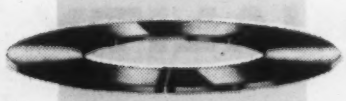
Mechanical Data on 2R25—
TENSILE STRENGTH RANGE—
Hard Rolled 242,000 • 270,000 or 299,000 PSI
Heat Treated 270,000 • 299,000 or 327,000 PSI
ELASTIC LIMIT (.01% Proof Stress)—From 156,000 to 192,000 PSI according to size and finish
MODULUS OF ELASTICITY—27.7 to 35.6 x 10^6 PSI according to size and finish
SIZES (with extremely close tolerances)
Thickness—.0016" to .035", Width—.039" to 3.94"
For further information on Sandvik 2R25, contact your nearest Sandvik office.

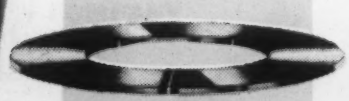
Hardened & Tempered Spring Steel


Annealed Spring Steel

Band Saw Steels


Flapper Valve Steel


Piston Ring Steels


Razor Blade Steel

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Sandvik stocks a wide variety of qualities and sizes of cold rolled specialty strip steels. In addition Sandvik has rolling, slitting, edge-filing and hardening and tempering facilities. *Send for your copy of this free brochure* which gives specific data on the leading types of Sandvik steels.

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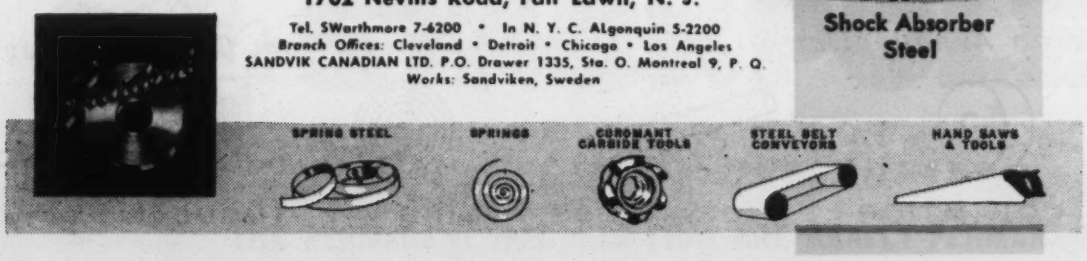

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What's new IN MATERIALS

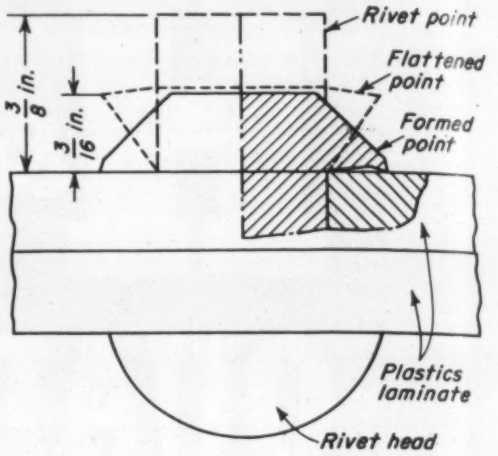


***Fig 1**—Stages in setting a rivet in a plastics laminate by using a two-step riveting technique.*

special button set is held at the head of a rivet.

2. A steel bucking bar or dolly, ground flat on one end, is held lightly against the point of the rivet; the dolly weighs 7½ lb and measures 1½ in. in dia and 15 in. in length.

3. As the rivet is driven into the plastics laminate the dolly is rolled over the rivet point by rotating its opposite end through a circular arc approximately 6 in. in dia. Rolling causes the rivet point to flatten quickly and easily. Uniformity of the circular motion determines the roundness of the formed point.

4. When the point of the rivet is flattened to half its original length, the dolly is reversed to bring the special set to bear against the rivet point. The circular motion is repeated to secure the rivet point against the surface of the laminate. (The riveting operation is shown

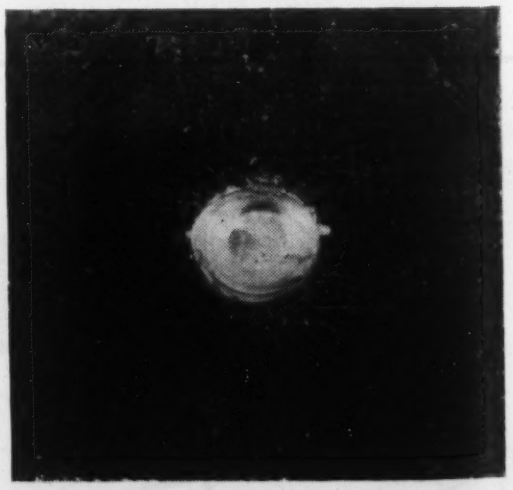


***Fig 2**—A ⅜-in. rivet point leaves no marks and is flat against the surface of a plastics laminate.*

THERMAFLOW®

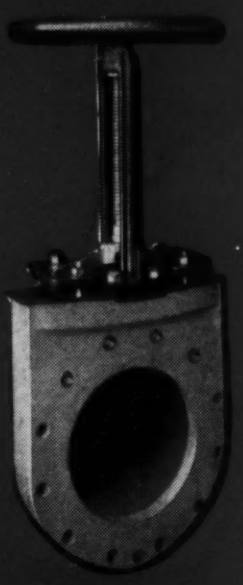
reinforced polyester molding compounds

Thermaflow compounds offer new opportunities, as replacements for metals or other plastics, to reduce manufacturing costs, improve performance and save weight. They offer high strength-weight ratio, superior corrosion resistance, and excellent electrical properties.

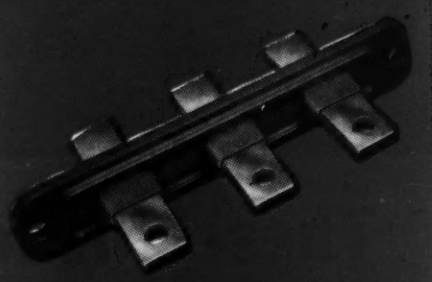
Mold them in standard compression or transfer presses at 275-350°F. at moderate pressures for uniform strength throughout.

Write for catalog giving complete data and molding information.

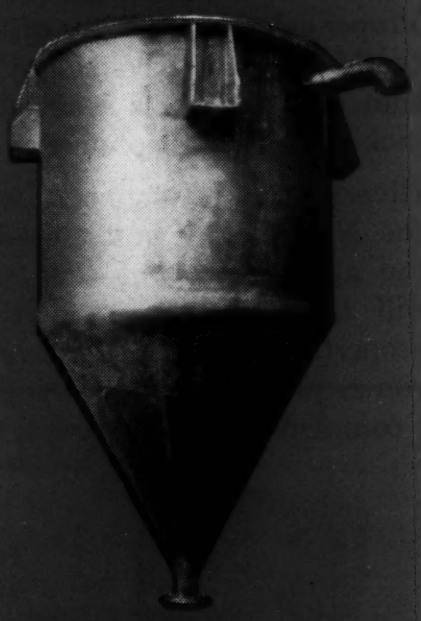
MECHANICAL PROPERTIES			CHEMICAL RESISTANCE						
THERMAFLOW	IMPACT STRENGTH	FLEXURAL STRENGTH	ACID	ALKALI	ORGANIC	BURNING RATE	HEAT DISTORTION	ELECTRICAL PROPERTIES	SPECIAL CHARACTERISTICS
100	12-24	20,000-25,000	Excel.	Excel.	Good	Slow	450°F	Good	best flow-chemical resistant
200	10-18	17,000-20,000	Fair	Fair	Fair	Slow	275°F	Fair	vibration resistant
400	10-16	18,000-23,000	Good	Good	Fair	Self extinguishing	450°F	Excel.	high impact electrical grade
500	10-16	18,000-23,000	Fair	Fair	Fair	Slow	>500°F	Good	high temperature
800	12-24	20,000-25,000	Good	Good	Fair	Self extinguishing	>450°F	Excel.	high impact electrical grade Meets Mil. Spec. MIL-M-14E, Type MAI-60
1000	3.2	6,000	Good	Excel.	Good	Slow	250°F	Good	smooth, glossy surface



THERMAFLOW resists corrosion: valve body withstands strong chemicals, costs far less than stainless alloys.



THERMAFLOW simplifies assembly: molded circuit breaker part replaces 3 smaller parts, cuts assembly costs.



ATLAC 382 used in chemical scrubbing tank by Haveg Industries for severe corrosion-resistance.

ATLAC® 382 POLYESTER RESIN

special properties with conventional cure

Exceptional chemical resistance and electrical characteristics at elevated temperatures (to 250°F.). High heat distortion point, reduced shrinkage. Low specific gravity.

Available in styrene or as a dry powder. Applications include chemical tanks, corrosion-proof structural pieces, laminates, pre-mix compounds, electrical impregnant.

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These Nickel alloy experts CAN HELP YOU PRODUCE A BETTER PRODUCT

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Riverside-Alloy engineers will work closely with you in choosing the Nickel alloy best suited for your product, analyzing not only the application, but the *fabrication* problems, as well. Only then will they recommend a Riverside-Alloy Nickel with the precise properties of temper and toughness, of fatigue and corrosion resistance you require. And they'll supply it in the *form* you need, too, from a complete variety of strips, wires and rods.

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H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

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schematically in Fig 1).

How rivets perform

We drove rivets with different point lengths (5/16, 3/8, 1/4 and 1/2 in.) into polyester-glass cloth and glass mat laminates to see how well the rivets performed. The ⅜-in. aluminum rivet was the best, as it left no visible marks on the surface and its point was flat against the laminate (see Fig 2.) Other rivets showed surface degradation at the formed points and were irregularly secured against the surface of the laminate.

We ran another test to determine how tightly the ⅜-in. and other rivet points were embedded in the plastics laminate. The test consisted of cutting off the formed rivet points at the shank end, then pulling the rivet out of the laminate by using a special testing device. No mechanical failures of the rivets occurred, and in most specimens the rivets remained tight in the laminate. The average values of pull-out force are given in an accompanying table.

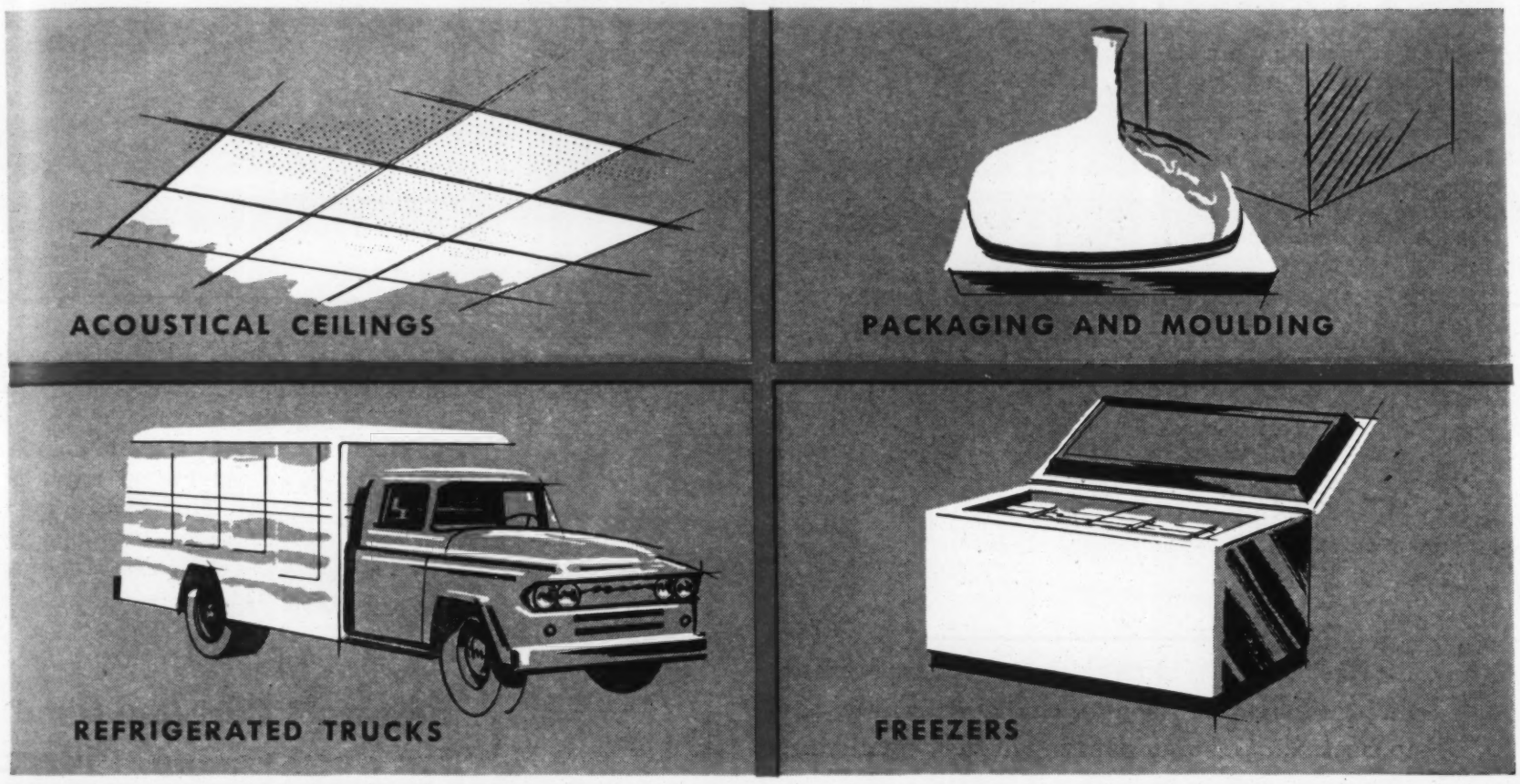
How method was developd

Our plastics riveting technique came out of experimental work in using a polyester-glass cloth laminate to insulate steel and aluminum from each other in submarine construction. A strong joint between

***Fig 3**—Kel-F bushings remain intact after riveting (top) and after joint failure (bottom).*

Thiokol RIGITHANE FOAMS

offer ideal properties for ease and versatility in fabrication



NEW THIOKOL Rigithane resin is the ideal foam for insulating, sound absorbing and vibration dampening applications. This new foaming resin offers great formulating flexibility . . . gives you a wide range of densities and properties. Rigithane can be "foamed-in-place" either by pouring or spraying – and cures at *room temperature*.

THIOKOL Rigithane foams combine extremely light weights with exceptionally high strength. Foams from Rigithane display excellent thermal insulation properties, as well as good sound deadening and vibration dampening characteristics. In addition, Rigithane foams can withstand temperatures up to 250°F with no degradation of physical properties. And they adhere strongly to many materials, including metal, wood, glass and fabrics.

As might be expected, Thiokol's Rigithane foams are finding wide use in a great many industries. They are particularly useful for insulating curtain walls, acoustical ceilings, food freezers and insulated panels for "reefer" or refrigerated trucks, as well as in protective packaging and light weight molding applications. In Rigithane, Thiokol can provide a foam custom built for your needs.

Thiokol®

CHEMICAL CORPORATION

780 NORTH CLINTON AVENUE • TRENTON 7, NEW JERSEY

In Canada: Naugatuck Chemicals Division, Dominion Rubber Co., Elmira, Ontario

®Registered trademark of the Thiokol Chemical Corporation for its liquid polymers, rocket propellants, plasticizers and other chemical products.

FOR MORE INFORMATION, mail coupon to Dept. 42, Thiokol Chemical Corporation, 780 North Clinton Avenue, Trenton 7, New Jersey.

Gentlemen: Please send me further details about THIOKOL Urethane Foams.

Firm_____

Street_____

City_____ State_____

Your Name_____

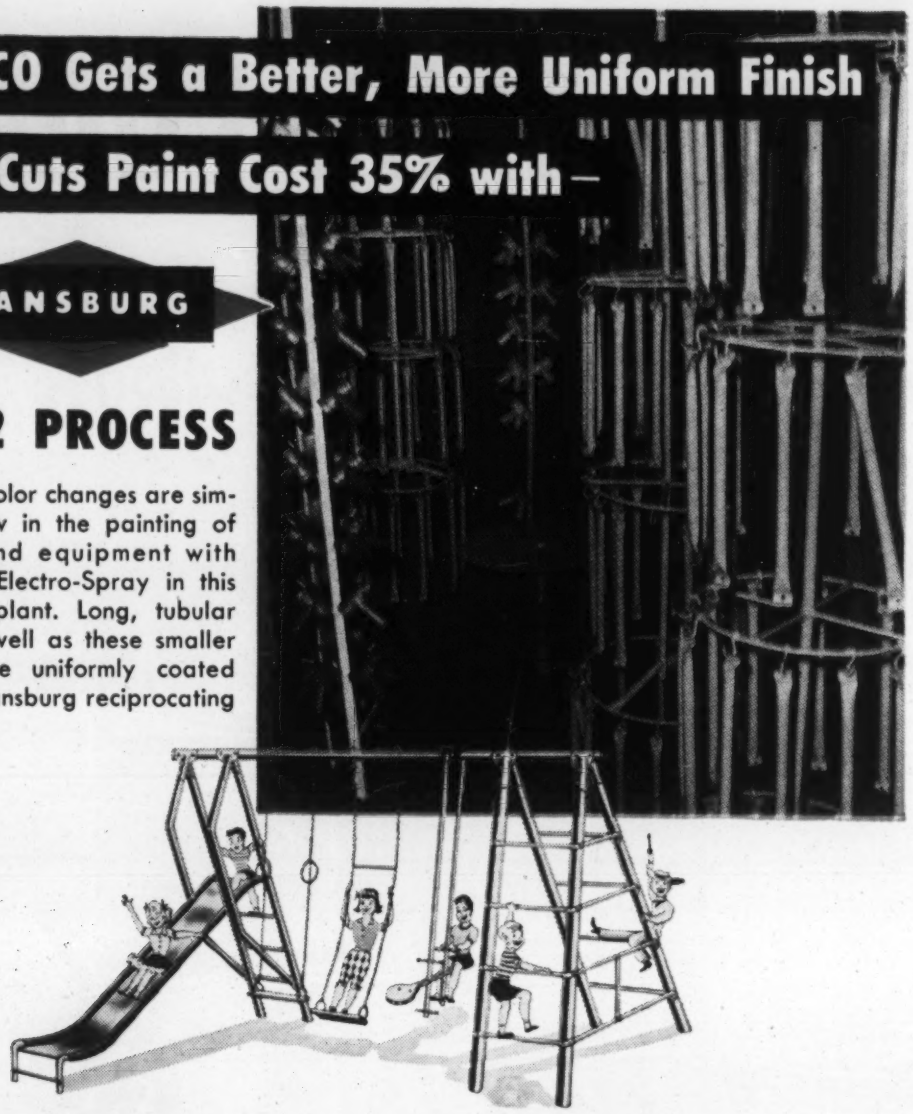
For more information, turn to Reader Service Card, circle No. 383

TURCO Gets a Better, More Uniform Finish And Cuts Paint Cost 35% with—

RANSBURG

NO. 2 PROCESS

Frequent color changes are simplified now in the painting of playground equipment with Ransburg Electro-Spray in this St. Louis plant. Long, tubular parts, as well as these smaller pieces, are uniformly coated with the Ransburg reciprocating disk.



QUALITY IMPROVEMENT! That was Turco Manufacturing's chief reason for changing from flo-coat to electrostatic spray painting of their quality line of playground equipment.

Not only is Ransburg No. 2 Process providing a higher quality, uniform coating on all parts, but Turco is saving 35% in paint cost!

Simplicity in color change with Electro-Spray is another important advantage here. With Turco's production methods, colors are changed 15 times in an 8-hour shift. Now, changes are made on the fly with no down-time. By contrast, the former "stop and go" method would mean over an hour's lost time in a day's operation.

NO REASON WHY YOU CAN'T DO IT TOO!

Whatever your product, if it's painted, we'd like to tell you more about the worthwhile savings and benefits which can be yours with RANSBURG ELECTROSTATIC PAINTING PROCESSES. Write for our No. 2 Process brochure which cites many examples of electrostatic spray painting on a wide variety of products.

Call or write

RANSBURG
Electro-Coating Corp.

For more information, turn to Reader Service card, circle No. 394

PULL-OUT STRENGTH OF RIVETS

Laminate	Undriven Point Length, in.	Ult Pull-Out Strength, psi
Polyester-Glass Cloth	¼	1900
	5/16	2100
	⅜	1800
	½	2300
Polyester-Glass Mat	¼	1800
	5/16	1400
	⅜	1600
	½	1500

the polyester-glass cloth laminate and dissimilar metals was achieved by fastening the laminate with ⅜-in. aluminum rivets at the aluminum plate and ⅜-in. mild steel rivets at the steel plate. The rivets were insulated with Kel-F bushings to absorb impact from the riveting gun (see Fig 3).

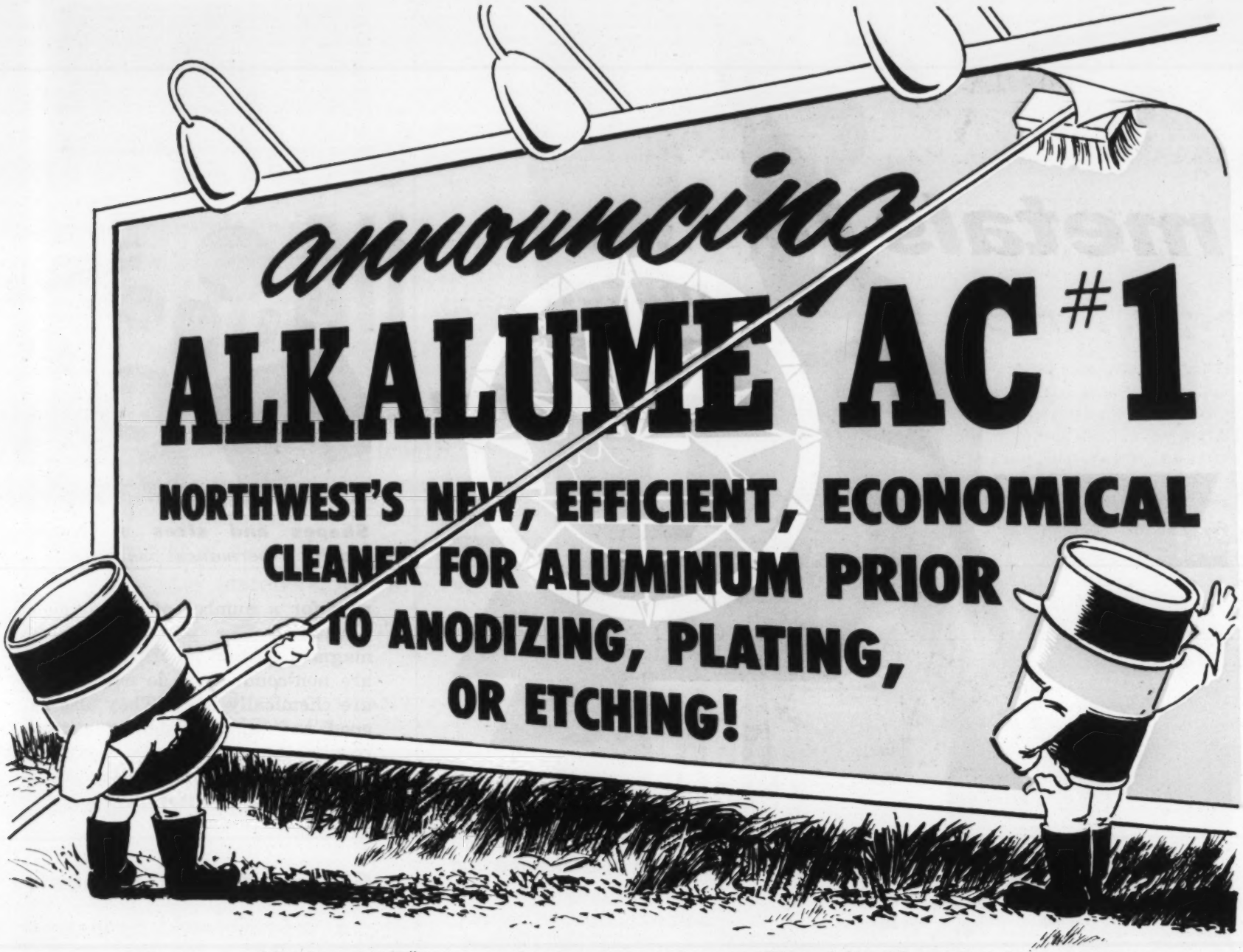
Sintered Carbide Used for Hard Facing, Fillers

Sintered tungsten carbide powders for hard surfacing, abrasives, diamond settings, oil field tools, plastics dies and other applications have been introduced by Shwayder Chemical Metallurgy Corp., 684 E. Woodbridge, Detroit 26. Called Mikrocarbide, the powders are composed primarily of sintered tungsten carbide with small amounts of titanium and tantalum carbides in a cobalt binder. Hardness of the individual particles is said to be about 91.5 Rockwell A.

For hard surfacing the material can be applied by arc, gas or brazing techniques to form a surface said to be more abrasion and erosion resistant than the conventional cast carbide powders. The powders are said to be particularly useful as a filler in plastics dies.

Permanent Magnets Are Lightweight

National Moldite Co., 248 South St., Newark 5, N. J. has developed lightweight permanent barium mag-



Alkalume AC#1 is a safe, easy to use, non-silicated liquid used at low concentration with water. This latest addition to Northwest's outstanding line of specialized chemicals for use with today's modern metals offers these desirable features—

- **Non-alkaline, non-etching, non-filming.**
- **Gives uniform, unblotched brilliance.**
- **Wets out unusually well.**
- **Ideal as follow-up to heavy-duty precleaner.**
- **Excellent as single stage cleaner for light soil.**
- **Economical to use.**
- **Unusually long service life.**
- **Non-hazardous, no offensive odor.**
- **No disposal problem.**

Got a Problem? Let our Cleaning Specialists help you!

Complete details will be sent upon request.

"The name NORTHWEST means first with the best."

LO HI pH

NORTHWEST CHEMICAL CO.

9310 ROSELAWN DETROIT 4, MICH.

For more information, turn to Reader Service card, circle No. 416

metals ... ...to match man's imagination

Conventional metals can no longer provide the solution to design, construction and performance problems confronting the aviation and missile industries, among others. That's why metallurgists and technicians in Wallingford's all-new laboratories are constantly researching metals that will keep pace with the imaginativeness of designers and engineers.

Now, Wallingford can deliver, *from available stock,* many of these stainless steels and super metals with special characteristics and properties:

SUPER ALLOYS

A 286 AM 350 AM 355
M 252 N 155 R 235 V 36
Rene 41 Zirconium (vacuum annealed)
Haynes 25 Hastelloy B, C and X
19-9 DL

FACILITIES FOR WIDTHS UP TO 27" — THICKNESSES DOWN TO .001 — EXTREMELY CLOSE TOLERANCES MAINTAINED.

Whatever your requirements, Wallingford can help you. Write to The Wallingford Steel Co., Wallingford, Conn.

THE WALLINGFORD STEEL CO.

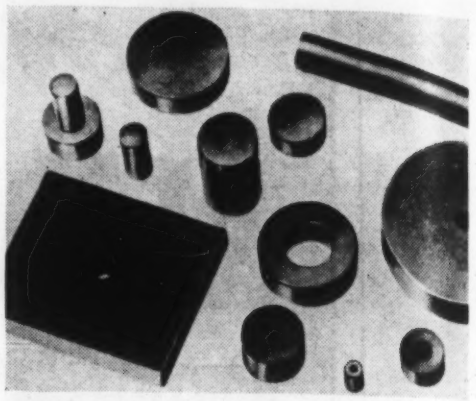
Progress in Metals for over 36 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy
WELDED TUBES AND PIPE: Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 467

What's new IN MATERIALS



Shapes and sizes *of National Moldite's permanent magnets.*

nets for a number of industrial applications. The producer says the magnets contain no critical material, are non-conductive, do not rust, and are chemically inert. They also have good resistance to demagnetization, require no pole pieces, have good storage life, and can be magnetized either before or after assembly.

Strong Epoxy Adhesive

A one-component, ready-to-use epoxy adhesive developed by H. B. Fuller Co., 255 Eagle St., St. Paul 2, Minn. is said to form bonds of over 5000-psi strength on aluminum and steel. Called Resiweld No. 105, the material hardens permanently when cured at a temperature of 350 F. According to the company, surfaces to be joined do not require clamping or other mechanical fastening during curing.

Cold Forging Doubles Fatigue Life of Bolts

Complete cold forging of large-diameter threaded bolts doubles their fatigue life, according to Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio.

Cold forged bolts were fatigue tested against hot forged and machined bolts. Results show cold forged bolts lasted 60,000 cycles as against an average of 31,500 cycles for hot forged bolts and 32,000 cycles for machined bolts. The cold forged bolts had a tensile strength of 92,900 psi compared to 76,400 psi for hot forged and 80,000 psi for machined bolts. The company says cold forg-

We Make Them All

When you need standard fasteners, regardless of diameter or length, Bethlehem is ready to serve you.

We make standard bolts and nuts in thousands of sizes. They're all top-quality fasteners, and in good supply, with same-day delivery on many items.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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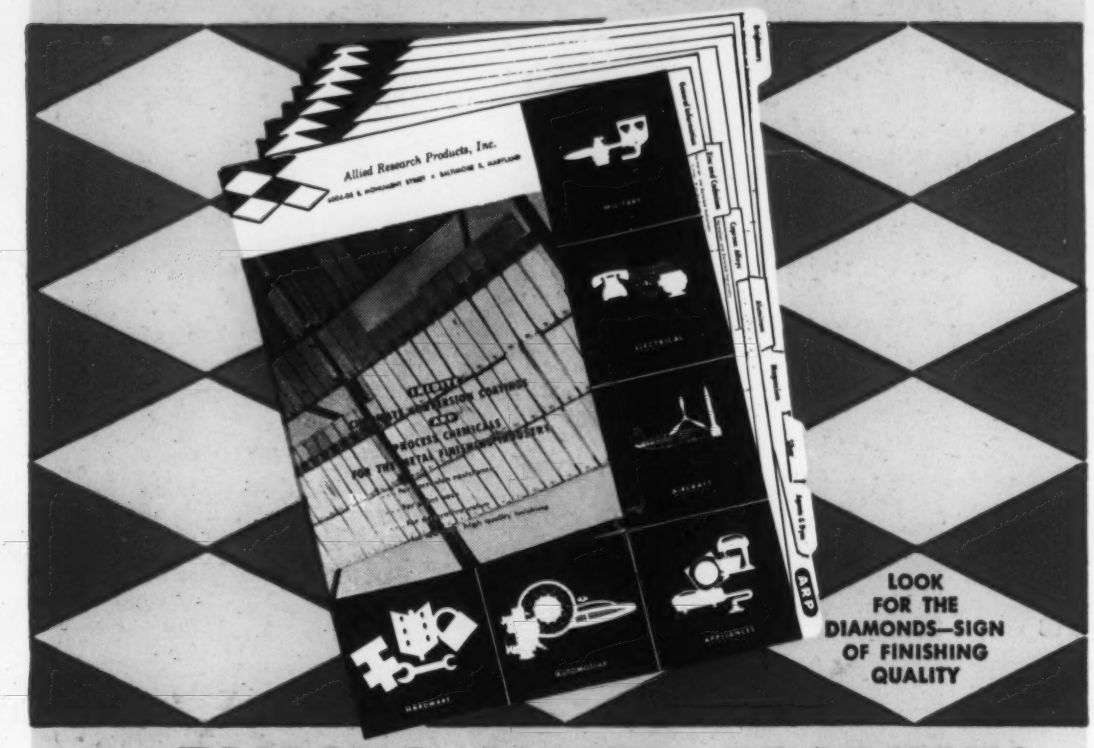
Useful Technical Data File...



on FAMOUS ALLIED PRODUCTS

For Finishing, Cleaning and Protection of Metals

Here's a wealth of technical information gathered as a result of extensive product research, development and use throughout the world. This comprehensive file explains and describes all products, gives applicable metals, appearance of film, purpose of products, typical applications, U. S. Government specifications, method of application and test results.

IRIDITE® The finishing industry's most complete line of chromate conversion coatings. Give peak corrosion resistance, a lasting paint base and widest choice of appearance in decorative finishing on

ZINC AND CADMIUM ALUMINUM CUPROUS ALLOYS MAGNESIUM SILVER

ARP® BRIGHTENERS Liquid and powder materials for barrel, still or automatic ZINC and CADMIUM plating. High chemical stability provides maximum quality at minimum cost. Liquids available in AUTO-FLO-PAK for economical automatic dispensing.

ARP® PROCESS CHEMICALS

WETTING AGENTS DETERGENTS DYES FOR IRIDITE FILMS

ARP® CLEANERS and DEOXIDIZERS Specially formulated to provide maximum performance with IRIDITE coatings on aluminum and zinc die castings.

IRILAC™ New method of protection incorporating corrosion inhibitors in a water-soluble polymer base which dries to an extremely thin, tough, durable coating —clear in color. Does not chemically affect base metal or any post treatments. Used as a protective treatment alone or to enhance value of post treatments.

Write now for your copy of Allied's Technical Data File, or call your Allied Field Engineer for full information on Allied products. He's listed in your phone book under "Plating Supplies".

Your Finishing Problems Invited

Our Research and Development Department will be happy to work with you to develop a finish for your needs.

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BALTIMORE 5, MARYLAND

***Manufacturers* of IRIDITE®, IRILAC™, ARP® Brighteners and Plating Chemicals—West Coast Licensee: L. H. Butcher Co.**

For more information, turn to Reader Service card, circle No. 403

What's new IN MATERIALS

***Giant bolts** are cold forged.*

ing retains the strength-giving grain flow of the fastener material (AISI 1018) and eliminates scale and possible decarburization in the head area.

Cleveland is turning out cold forged bolts in diameters of ⅞ to 1¼ in. and in lengths up to 10 in. The bolts are available with either hexagon or square heads.

Rigid PVC Sheet

A rigid vinyl sheet said to have unusual strength and stiffness in light as well as heavy gages is being produced under the name of Seilon TTT by Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio. The sheet is made of Pliovic S50, a polyvinyl chloride resin supplied by Goodyear Tire & Rubber Co. Potential uses for the sheet include vacuum formed products such as luggage, signs, displays and maps.

The rigid PVC sheet has a tear strength of 900 lb per in., a tensile strength of 6000 psi, a notched Izod impact strength of 16.7 lb per in. of notch at room temperature, and a heat distortion point of 158 F at 264 psi.

Seilon TTT is supplied in calendered sheets in gages from 0.010 to 0.030 in. and in widths up to 60 in. It is also supplied in laminated sheets in thicknesses up to 1 in. and in sizes up to 4 x 8 ft. Either satin or embossed surfaces are available.

Atlas missile test tower

MISSILE LAUNCHING VALVE COST REDUCED 30% WITH ESCO CASTING

Problem: Fabricating high pressure gas tank butterfly valve bodies for missile component manufacturer Convair-Astronautics, San Diego, California, proved unsatisfactory. Consisting of wrought stainless steel flanges and tubes welded together and machined, valve costs were high. Weld seams were susceptible to intergranular corrosion and gas leakage. This was a critical installation as these units had to withstand test temperatures ranging from −65° to 500° F., at 2,000 vibrations per second and at stresses up to 15 gravity units.

Solution: The valve body was redesigned as a casting. One-piece design alloy steel improved strength and corrosion resistance and practically eliminated the danger of gas leakage. *ESCO* centrifugal casting technique permitted casting six 180-pound valve bodies simultaneously. Resulting savings in material and labor amounted to 30 per cent of previous costs.

You can simplify your design problems by calling an ESCO engineer today.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

2163 N. W. 25TH AVE. • PORTLAND 10, OREGON
MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

For more information, turn to Reader Service card, circle No. 410

Shown 1/18 actual size

How missile designers can use HACKNEY deep drawing methods

Shown here are a few shapes, shells and missile components produced at production-line speed by *Hackney Deep Drawing Methods.* They were designed to reduce weight without sacrificing strength, save production or assembly time, and lower costs.

If you wish to consider *Hackney Deep Drawing Methods,* keep in mind the following specifications and the fact that our engineers are available for consultation at any time.

Shapes: Cylindrical, spherical, conical or tapered.

Capacities: From 1 quart to 100 gallons.

Diameters: From 3 inches up to 32 inches.

Depths: Up to 110 inches. Two half-shells are easily welded for extra length or symmetrical design. Open ends can be closed by spinning to give an entirely seamless cylinder.

Blank thicknesses: 16 gauge and heavier.

Wall thicknesses: For working pressures up to 5000 psi in smaller diameters, up to approximately 400 psi in larger diameters.

Metals: Steel, stainless steel, nickel, aluminum, magnesium, copper and many alloys.

Send sketch and details of your problems to our Engineering Department.

Pressed Steel Tank Company

Manufacturer of Hackney Products

1442 South 66th Street, Milwaukee 14, Wis.

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Hackney MILWAUKEE — DOWNINGTOWN IRON WORKS

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 413

What's new IN MATERIALS

Glass-Epoxy Laminate Is Flame Retardant

An electrical grade glass-epoxy laminate, introduced recently by Continental-Diamond Fibre Corp., Newark, Del., is said to have excellent flame and heat resistance. The producer says the laminate can be used continuously at temperatures up to 300 F and intermittently at temperatures above 300 F. In addition, because the laminate contains flame retardant additives, it will not continue to burn when removed from a flame.

Applications for the laminate include: switchgear components, such as circuit breaker arms and insulating barriers; panels and terminal boards; and radio and television relays.

The laminate is available either in plain form for power applications or in metal clad form for printed circuitry. It is supplied in sheet sizes ranging from 0.010 to 1 in.

Coated Graphite Parts Perform Well at 5000 F

Development of impervious coatings giving graphite good oxidation resistance at temperatures up to 5000 F, combined with good abrasion resistance and adhesion characteristics, was announced recently by Minnesota Mining & Mfg. Co. The coating, composition of which has not been revealed, is applied to graphite by a new bonding process which 3M says is superior to any previous graphite bonding technique.

Coated graphite parts are availfrom American Lava Corp. (a 3M

***Nose cone** is a potential use for 3M's coated graphite.*

For more information, circle No. 374 >

New easier way

... to use stainless steel lock wire!

Note how the lock wire, uncoiling from the inside, is dispensed as needed from a hole in the top of this compact 1-pound package. No wild uncoiling! Moreover, the wire is better protected, handles easier and faster, with less waste, and with greater safety!

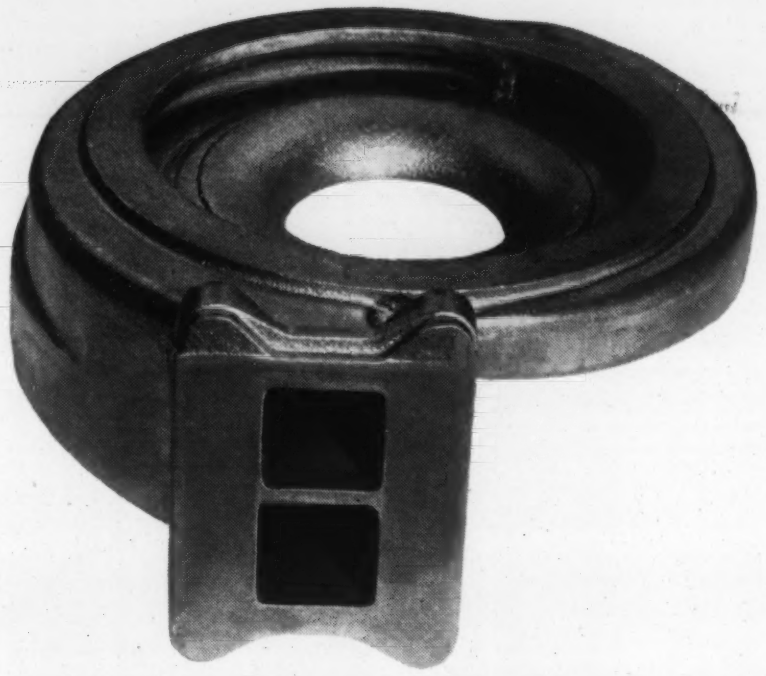
Here is a new National-Standard packaging development that is a natural for most safety lock wire uses in equipment manufacture, assembly and servicing.

For production operation requiring larger capacities, National-Standard offers lock wire on practical 5 and 10-pound disposable spools that may be spindle-mounted.

Check with National-Standard on the spooling of your choice and on stainless steel lock wire in any diameter from 0.020 to 0.067 and to government specifications: QQ-W-423, AN-W-24, MIL-W-6713 or AMS-5685-C.

NATIONAL STANDARD

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires*
WORCESTER WIRE WORKS, Worcester, Mass.; *music spring, stainless and plated wires, high and low carbon specialties* • **REYNOLDS WIRE, Dixon, Ill.;** *industrial wire cloth*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • **ATHENIA STEEL, Clifton, N. J.;** *flat, high carbon spring steels*



THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

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HAMILTON FOUNDRY

The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491

For more information, turn to Reader Service card, circle No. 464

subsidiary), Cherokee Blvd. & Manufacturers Rd., Chattanooga 5, Tenn.

Potential uses

Structural parts for missiles and jets are some of the potential uses for coated graphite, according to J. R. Johnson, 3M's atomic energy coordinator. He says coated graphite shapes have been exposed intermittently to high velocity oxidizing gases at temperatures in excess of 5000 F without being damaged. Only after prolonged continuous exposure was the coating penetrated, he says.

In addition to aircraft parts, 3M's coated graphite has potential use in such nuclear applications as control rods, coolant tubes, heat exchangers, and jacketings for ceramic fuel elements. In other fields, such as the chemical and metallurgical industries, the material might be used for tubes, containers, pipes and molds.

Properties

Johnson says various coated graphite shapes have been subjected to temperatures from 1800 to 2700 F for several hundred hours without any measurable oxidation of the graphite, and immersed in boiling acids, including aqua regia, for weeks without damage. The parts have also been exposed to 1600 F steam and carbon dioxide (in separate tests) for several hundred hours without damage.

The company says application of the impervious coating produces no undesirable changes in the physical properties of the graphite and, except for the dimensional change resulting from the thickness of the coating, does not alter the shape or size of the part.

Fusion-Coated Vinyl Resists Alkalis, Acids

A powdered vinyl resin has been added to a line of specially formulated resins for a fluidized coating process called Whirlclad (see M/DE, Apr '58, p 200). In the coating process, parts are preheated and dipped into a fluidized bed of dry powders which bond by fusion onto the surface of the part.

Developed by National Polymer Products, Inc., 125 N. 4th St., Reading, Pa., the powdered vinyl resin,

Dyed coatings produce many colored finishes not shown here.

Result of chromate treating zinc in ***UNICHROME DIPS:***

eye appeal... corrosion protection... low cost

ZINC PLATE is a good finish as far as it goes. It can be made to go much further with chromate treating. It can be transformed into a number of outstanding finishes... with extra life, extra eye appeal, extra sales stimulation ... all at little extra cost.

One of the widest lines of chromate treating compounds available, Unichrome Dips can satisfy virtually any requirement ... of product, production method, and pocketbook. Brilliantly clear finishes have been produced for a material cost as little as 30¢ per 1000 sq. ft. of treated surface! Products can be clad for optimum corrosion resistance in a matter of minutes. And you also get an ideal base for clear, dyed, or pigmented organic coatings.

Along with wide selection and quality finishes, goes service. Service from solutions which give good "mileage" Service from M&T engineers who have long experience in metal finishing, and zinc finishing problems in particular. Send for detailed information and handy Unichrome Pick-A-Dip Chart.

METAL & THERMIT
CORPORATION
GENERAL OFFICES: RAHWAY, NEW JERSEY

Pittsburgh • Atlanta • Detroit • East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, On

For more information, turn to Reader Service card, circle No. 499

The Sylvania Internal Circuit Breaker was developed primarily for protection of electric motors such as are used in windshield wipers, window lifts, seat actuators, antenna lifts, air compressors, vacuum boosters and other automotive power equipment. Mounted adjacent to the brush holders, this two-piece bimetal breaker is ambient compensated, self-re-closing and protects against locked rotor or stall current conditions. All in the series are mounted on a standard base which permits easy design within small motor space limitations.

The two legs are Chace Thermostatic Bimetal. The U-shaped leg has the low expansive side on top, while the short straight section is opposite, making the unit partially ambient compensated. The design insures minimum derating from initial SAE calibration at ambient temperature levels of —20° to 200°F. The long initial on-time under load eliminates trip-outs due to short term overloads.

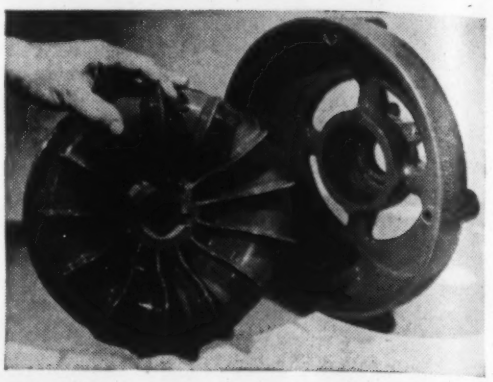
As the modern motorcar becomes more complex with its scores of motor-driven devices for safety, comfort, convenience and improved operation, the hazards of fire and serious damage are multiplied. Sylvania offers "permanent protection" and "continuous service" based on the always predictable performance of our precision product. Our third of a century in thermostatic bimetal development and production is positive assurance that your two and a half to six thousand dollar investment and Sylvania's reputation are in good hands. And when your need for a temperature-actuated device approaches the design stage, send for our 1958 edition of "Successful Applications of Chace Thermostatic Bimetal," containing many pages of valuable design data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service card, circle No. 473

What's new IN MATERIALS

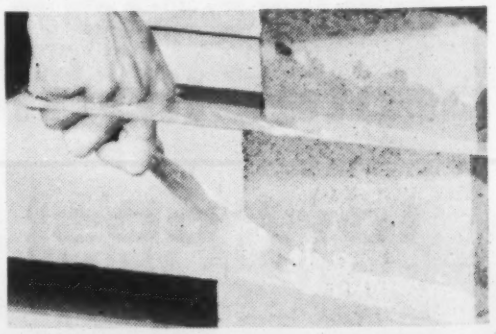


***Washing machine parts** are a typical application for Corvel vinyl coatings. The fusion-bonded finish did not blister when immersed in detergents for 21 days.*

called Corvel, is said to provide a tough, resilient finish to dishwasher racks, washing machine parts, battery cases, electrical parts, hardware, decorative panels and novelties.

Better Chromium Plate with Thicker Coatings

Longer lasting and better looking chromium electroplates on automobile trim and other parts might be achieved by increasing the thickness of the chromium electroplate three to six times that normally applied over bright nickel, according to C. H. Sample, International Nickel Co. A one-year corrosion test at the company's Kure Beach test station shows

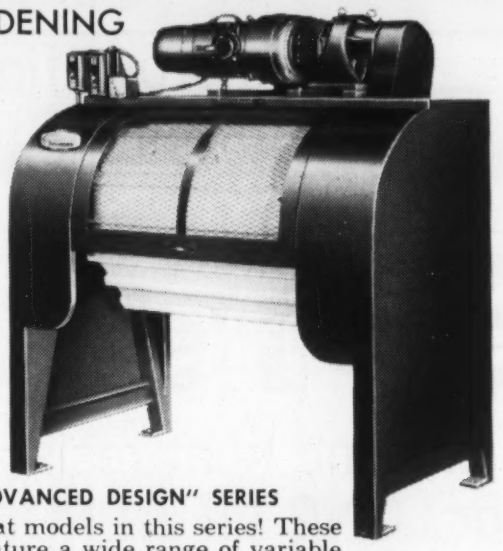


Underwater joining — The two blocks of wet concrete shown above are being joined together with a new epoxy adhesive that can be applied to materials under water. Developed by Furane Plastics Inc., 4516 Brazil St., Los Angeles 39, Calif. and called Epocast 546, the adhesive cures in wet locations to metals, concrete, stone and other materials.

FOR DEBURRING • DESCALING • GRINDING • BURNISHING • POLISHING • FORMING RADII
MICROINCH FINISHING • RUST-INHIBITING • WORK-HARDENING

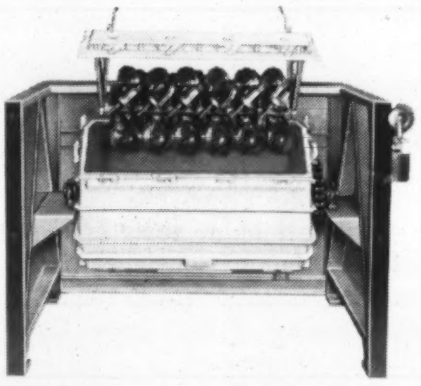
ALMCO

has the right barrel finishing equipment for you!



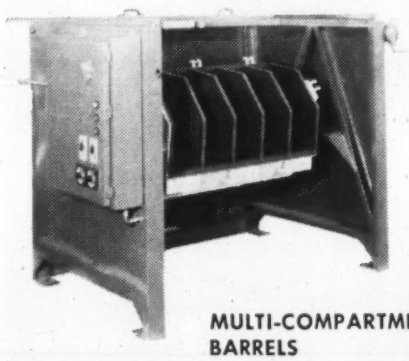
ALMCO'S "ADVANCED DESIGN" SERIES

Thirteen great models in this series! These machines feature a wide range of variable speeds (infinite from 6 to 30 r.p.m.), making possible economical deburring and finishing of the greatest variety of parts. Each unit has Almco's exclusive design features and rugged construction to stand up under all types of punishing applications.



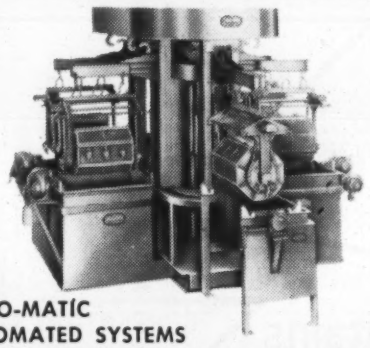
"FIXTURE" TYPE BARRELS

Pioneered by Almco for processing large and intricate parts. Custom designed fixtures hold parts securely, prevent part-on-part impingement and allow abrasive action to reach all surfaces, cavities, slots, etc. Barrels have automatic forward and reverse controls. Almco also offers integrated materials handling systems for further barrel finishing economies.



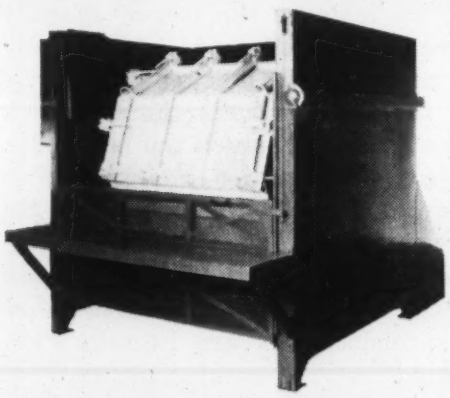
MULTI-COMPARTMENT BARRELS

Do you have these deburring and finishing problems — wide variety of parts or small quantity runs where fixtures would be too costly? Or short to medium cycle runs where you could *re-use* compound for several runs? Lack of floor space for several machines? An Almco custom-designed multi-compartment barrel may give you a cost-saving answer. Automatic forward and reverse. Any combination of compartments and doors.



SUB-O-MATIC AUTOMATED SYSTEMS

Almco's exclusive submerged unit is an automatic, "assembly line" system for micro-precision deburring and finishing of small parts in quantity. Saves labor, speeds up processing and flow of high production parts. One man for example can operate this equipment and handle as many as 192 barrel loads per 16 hr. day. Slashes compound expense to minimum because compounds can be re-used for days at a time. These submerged systems can also be obtained in non-automated, straight line systems.

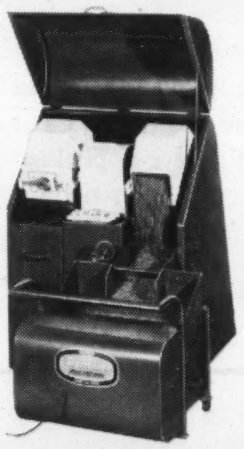


CUSTOM-DESIGNED BARRELS

Almco designs and manufactures special barrels of all types for problems where standard equipment cannot be effectively used. These range from the smallest type to the largest fixture barrel such as the 60" diameter x 60" length barrel shown above. Special large diameter barrels with double flat or triple flat doors are also available to accommodate extra large parts and to allow abrasive media to flow freely over the outer periphery of the part. Your special problems may be solved with one of Almco's custom-designed barrels. Material handling systems can also be closely coordinated with special barrels.

YOUR SAMPLE PARTS PROCESSED without obligation in this modern Almco test lab! Simply write on letterhead for address of nearest Almco lab or send parts direct to Albert Lea, Minn. Enclose specifications desired. Complete free report includes recommendation. 52 PAGE BARREL FINISHING HANDBOOK SENT ON REQUEST.

Almco deburring and finishing machines are ruggedly constructed to perform on a round-the-clock basis. They incorporate the best engineering design required in the industry — your assurance of versatility and economical processing of work parts. Optional equipment includes material handling devices and systems, automatic forward and reverse, double or triple flat doors, single and dual timer controls for automatic delay starting and stopping, perforated drain doors for flushing and rinsing, unloading devices, etc. Also a full and complete line of Almco Supersheen barrel finishing compounds and media of all types made especially for use with Almco precision barrel finishing equipment.



SMALLER MACHINES

Twin barrel machines manufactured by Almco are the standard of the industry for shops processing small lots of parts and for companies with large lots of small parts. Also ideal for sample processing, barrel finishing research and development work, and as auxiliary equipment. These units are Almco engineered to the highest specification standards and include operational and safety features found on larger Almco machines.

ALMCO

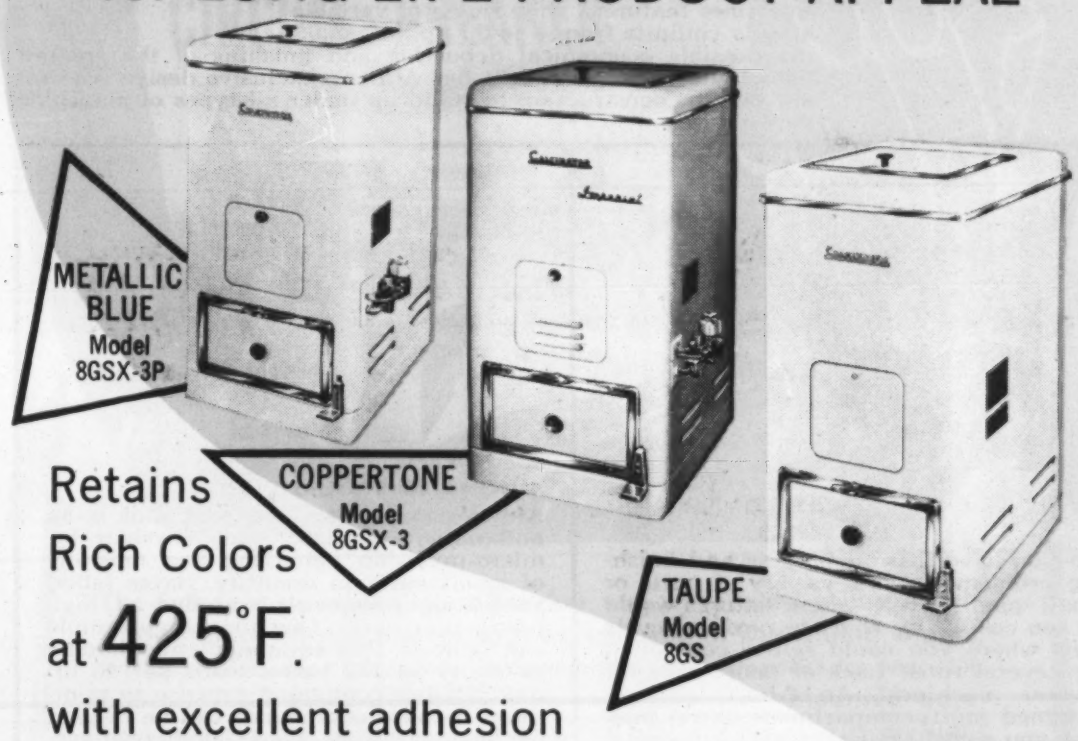
QUEEN PRODUCTS DIVISION, KING-SEELEY CORP.
310 MARSHALL STREET, ALBERT LEA, MINNESOTA

Sales and Engineering Offices in Chicago, Detroit, Los Angeles, Newark, New Haven, Philadelphia and London, England.

Designers and Builders of all types of Barrel Finishing Equipment for the Metalworking Industry

For more information, turn to Reader Service card, circle No. 477

the
glamorous finish of
Calcinator home incinerator
is
Sicon®
Silicone heat resistant finish
for LONG LIFE PRODUCT APPEAL



Retains
Rich Colors
at 425°F.
with excellent adhesion
and mar resistance

Sicon, the first high temperature finish to break the "heat barrier" in colors, is specified for all Calcinator home incinerators. A wide range of colors is employed: Metallic Blue, Coppertone and Taupe, as shown above; also Yellow and Turquoise. These smart Sicon enamels lend compelling eye-appeal on the sales floor. Equally important, their ability to retain their rich colors and gloss in every day service—exposed to temperatures in the 425°F. range—has helped produce thousands of satisfied Calcinator users. Sicon is easy to apply by brush, spray or dip. At Calcinator it is hand sprayed and baked by gas-fired ovens for 20 minutes at 425°F.
Sicon's excellent adhesion and film stability has led to its use on scores of applications, of widely varying heat resistance requirements up to 1000°F. Midland engineers will be glad to analyze your problem and suggest a formula. Send us all details.

Write for Literature
Dept. J-1

MIDLAND *Industrial Finishes Co.*
Waukegan, Ill.

ENAMELS SYNTHETICS LACQUERS
VARNISHES

Sicon

For more information, turn to Reader Service card, circle No. 502

What's new IN MATERIALS

that the corrosion resistance of a chromium-plated bright nickel sample is much improved when thickness of the chromium electroplate is increased from 0.01 to 0.06 mil.

Sample, speaking before the recent SAE annual meeting, said chromium plating seems to have an adverse effect on the protective value of bright nickel electroplates because of hydrogen embrittlement. He says heavier chromium electroplates might fill or bridge cracks in the nickel electroplate caused by hydrogen embrittlement.

Silicon Crystal, 2 Oz, Has High Strength

Dislocations or rows of out-of-line atoms that scientists blame for making metals "much weaker than they ought to be," have been completely eliminated in a large silicon crystal made by a new growing technique. The crystal, weighing about 2 oz, is similar in purity to silicon used for transistors and other semiconductor devices and is extremely strong.

The crystal growing technique, developed by General Electric's Research Laboratory in Schenectady, N. Y., involves the use of specially tapered "seeds" made of extremely pure material. The shape and purity of the seeds reduces thermal shock when they first touch the hot molten silicon from which the crystal is grown. Equally important in the growing technique, say GE scientists, is pulling the crystal in the proper crystallographic direction so that dislocations are literally "left behind" as the crystal grows.

Other dislocation-free metals have been made at GE and other research laboratories. In the case of iron, strengths up to nearly 2,000,000 psi —five times the tensile strength of the strongest piano wire—have been observed.

Conductive Silver Ink for Printed Circuitry

A conductive silver ink that can be directly printed on the surfaces of nonmetallic tubes has been de-

For more information, circle No. 400 ➤

DESIGN ENGINEERING DATA*

A New, LOWER COST– High Efficiency Fluorocarbon

RULON®

- newest, *most versatile* "SUPER TEFLON".
- *Lowest priced* of all comparable fluorocarbons.
- a modified TEFLON fluorocarbon enhanced by a superior blend of additives and reinforcing agents.
- an *accepted, tested* and *proven* TEFLON offspring with broader, more efficient and more economical applications.
- a dynamic Design and Engineering material: super performance with *improved* properties.

TESTED RULON PROPERTIES:

(as compared to TEFLON†)

SUPERIOR:

- Wear Resistance
- Hardness
- Stiffness
- Cold Flow
- Deformation Under Load
- Compressive Strength
- Thermal Conductivity

SIMILAR:

- Elongation
- Impact Strength
- Tensile Strength
- Electrical Insulation

SAME:

- Low Coefficient of Friction
- Extreme Heat Resistance
- Chemical Corrosion Resistance
- Non-flammability
- Outdoor Durability
- Zero Water Absorption
- Flexural Strength
- Non-stick Properties

†DuPont's TFE Fluorocarbon Resin

(Write for actual values)

PROVEN RULON APPLICATIONS

ELECTRICAL

Relays, Potentiometers, Antennae, Terminals and Connectors, Bushings and Washers.

CHEMICAL

Bearings for Acids and Dyes; Non-toxic Bearings for Food and Liquid Processing; Oil-free Bearings; Freon-resistant Seals; Refrigeration Seals.

MECHANICAL

Piston Rings, Torque Control Bushings, Textile Bearings, Rotary Seals, Cam Followers, Pump Bearings, Cups and Seals, Thrust Washers, Gaskets and Packings, Valve Seats.

(Write for actual applications)

RULON® a "super-TEFLON" whose properties and lower cost create applications never before possible for a designed-in and engineered material. *RULON* is the answer to a low-cost replacement for sintered metals, ball bearings, wood, glass, ceramics and expensive fluorocarbons. Select RULON *for more and longer performance at a lower cost.*

Write for further information and prices.

*plastics division:

Dixon Corporation

BRISTOL RHODE ISLAND *Established* 1

Sub-Micron
Disperser Valve

•

Handling Solid-
Fluid Materials

•

Pressures 5000 to
8000 p.s.i.g.

•

Flow Velocity
57,000 ft. per min.

KENNAMETAL* components help valve a 646 mile-per-hour flow!

In processing solid-fluid dispersions for paints, dyes, inks and other products, the materials move at almost supersonic speed through this valve. Ordinary materials in the path of such abrasive materials practically "melt" away. The designers' only answer was an *extraordinary* material . . . and they found it in Kennametal Tungsten Carbides.

The erosion-, abrasion- and corrosion-resisting properties of Kennametal not only extend the life of the most vulnerable valve parts but improve batch uniformity and help maintain exacting process requirements involving extreme turbulence, high velocity and a shattering impact.

Often the designer's most difficult problem is not just to blueprint a new device, but to find material that will give components the necessary service qualities. If you need unusual resistance to erosion, abrasion or corrosion . . . materials that retain their normal properties under prolonged exposure to temperatures of 2200°F and above . . . materials with a YME three times the rigidity of steel . . . you may find the answer in a Kennametal composition. For more information, send for Booklet B-111A, "Characteristics of Kennametal." Write KENNAMETAL INC., Dept. MDE, Latrobe, Pa.

3174

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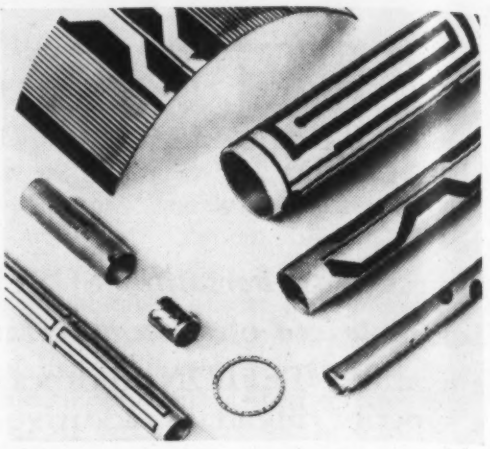
INDUSTRY AND
KENNAMETAL
...Partners in Progress

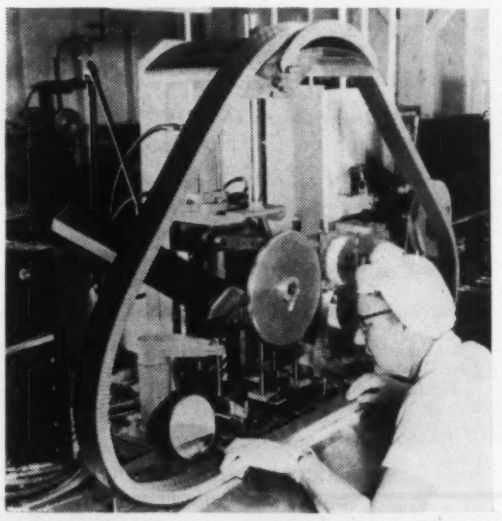
For more information, turn to Reader Service card, circle No. 405

What's new IN MATERIALS



Direct-printed tubes *can be used as instrument housings, faraday shields, resistors, commutators and microwave parts.*

veloped for printed circuitry. Marketed by J. Frank Motson Co., Flourtown, Pa., the ink can be applied to tubes having an i.d. as small as 0.020. It is especially recommended for application to such nonconducting materials as TFE, Kel-F, epoxy, silicone, polyester and phenolic resins; ceramics; and glass.



Honeycomb structures — Shown above is a machine that turns out a continuous stream of honeycomb structures. Developed by Solar Aircraft Co., the machine corrugates very thin metal strips (half as thick as a human hair) and welds them layer by layer into a completed structure. Solar has licensed Swedlow Plastics Co., 6986 Bandini Ave., Los Angeles, Calif. to manufacture and sell its honeycomb structures. They are available in type 321 stainless steel, Inconel, Inconel X, Inco 702, Thermenol, titanium and zirconium.

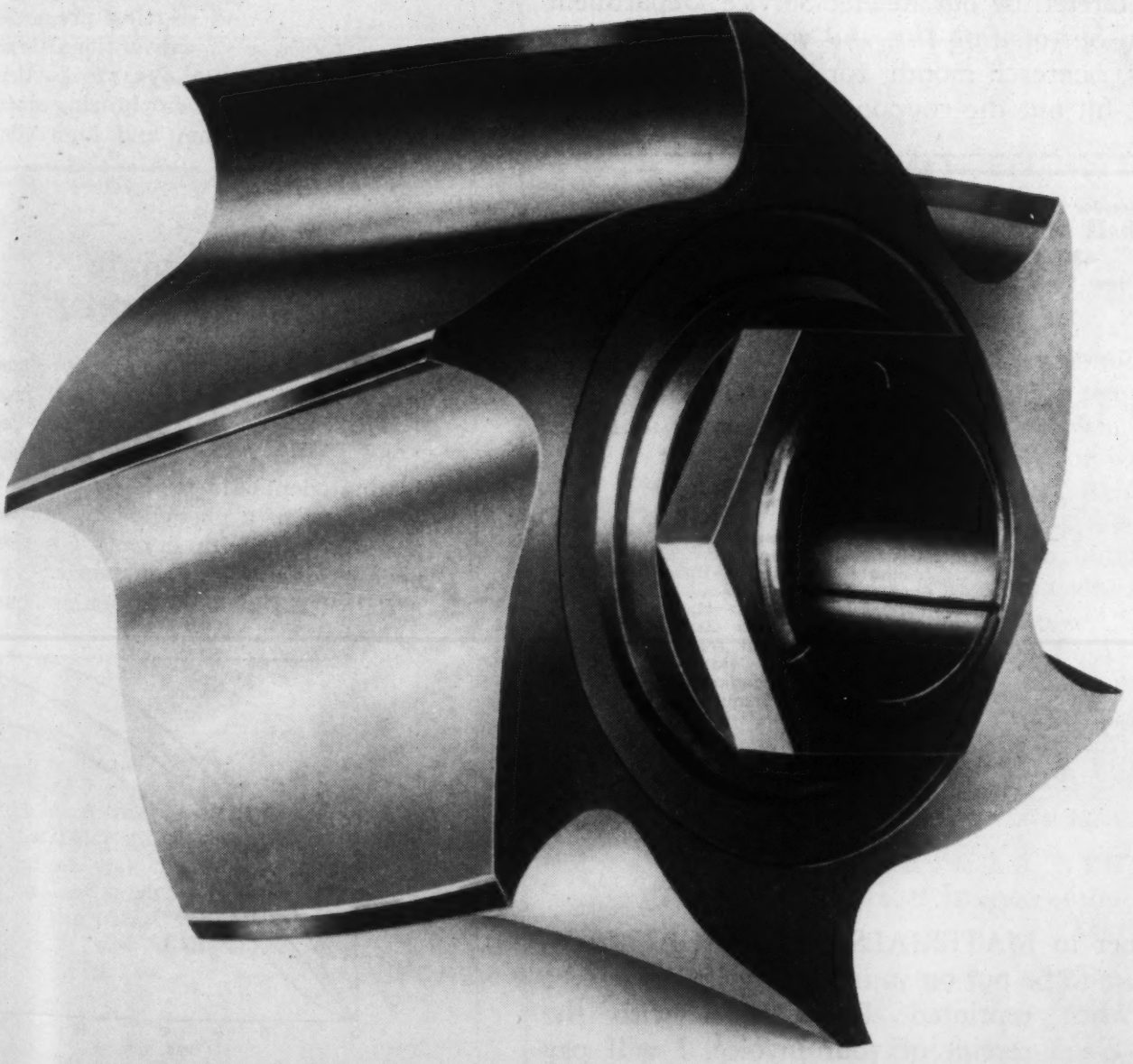
For more information, circle No. 496

NOW: Higher strength costs you less! Specify TENZALOY*, the self-aging aluminum alloy that needs no heat treatment! TENZALOY is a corrosion resistant aluminum alloy that ages at room temperatures, gives high strength properties superior to those normally obtained only by solution treating, quenching and artificial aging. And these properties are stable, proved by conclusive test data taken over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds, and many permanent molds. TENZALOY will not "grow". It takes a brilliant polish and anodizes clear white. Write for TENZALOY Bulletin No. 103 or call one of Federated's 22 sales offices. Federated Metals Division, 120 Broadway. New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

FEDERATED METALS DIVISION OF

ASARCO

AMERICAN SMELTING AND REFINING COMPANY



**TENZALOY is one of a complete range of Federated aluminum casting alloys. These and hundreds of other quality controlled non-ferrous metal products are produced in the 11 plants of the Federated Metals Division.*

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***Curved assembly** is a typical application for Nicrobraz sheet.*

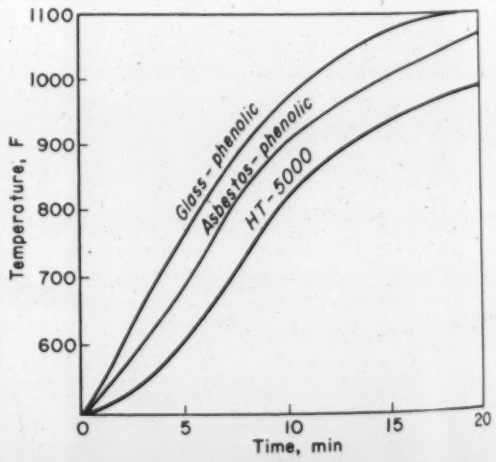
Ni-Cr-B Brazing Sheet

A line of nickel-chromium-boron brazing alloys is now available as flexible sheets in sizes from 0.015 to 0.060 in. thick. The alloys, called Nicrobraz and supplied by Wall Colmonoy Corp., Stainless Processing Div., 19345 John R. St., Detroit 3, have flow and wetting properties equal to those of conventional brazing alloys. The alloys are particularly recommended for brazing stainless steel, titanium and high alloy steels.

Plastics Laminate Insulates at 2000 F

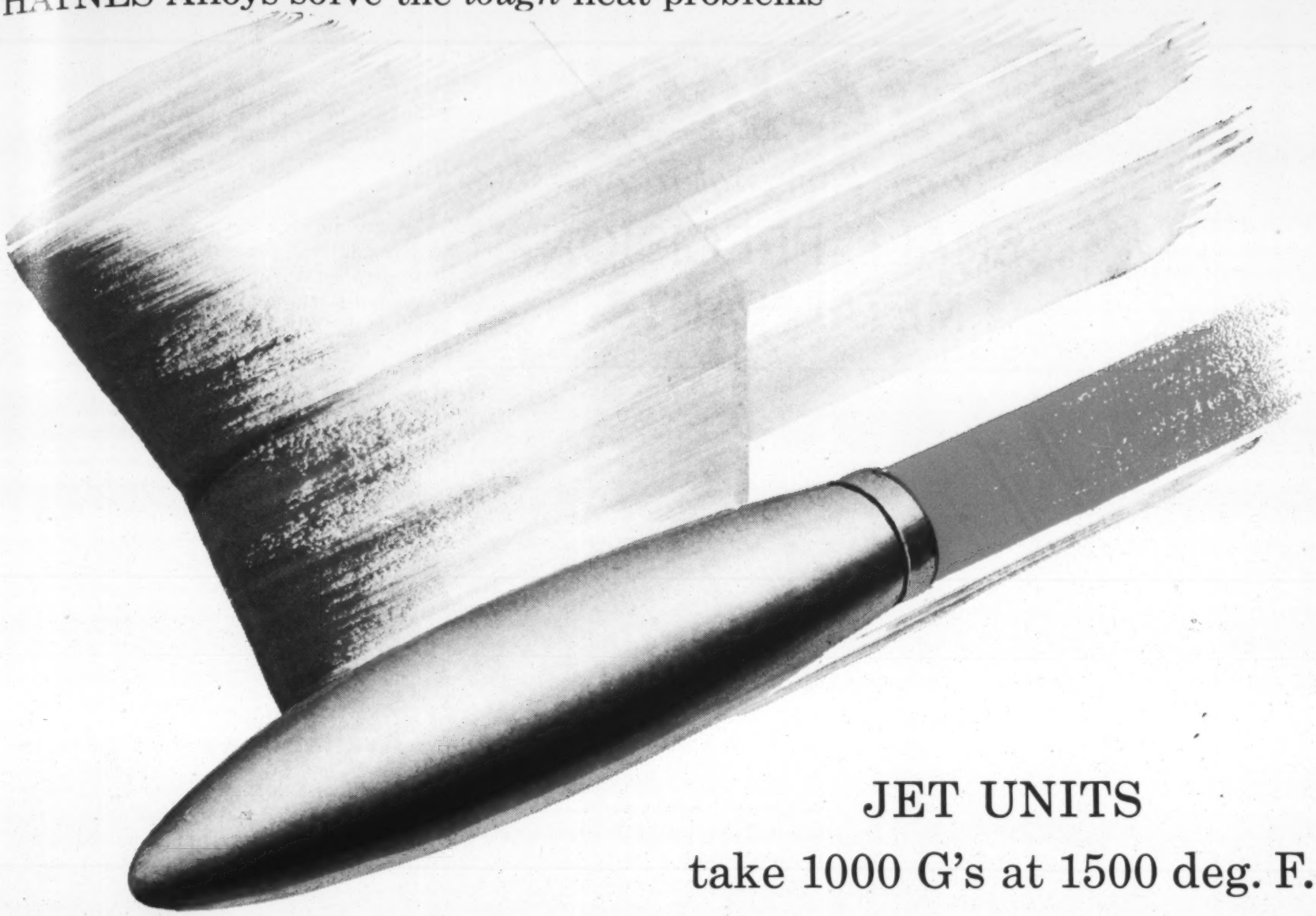
A promising material for nose cones and other missile parts has been developed by Taylor Fibre Co., Norristown, Pa. It is a composite laminated plastic made by alternating layers of a phenolic-impregnated asbestos mat with layers of a phenolic-impregated nylon fabric.

Called HT-5000, the plastics lami-



***Insulating properties:** HT-5000 vs other plastics.*

HAYNES Alloys solve the *tough* heat problems



JET UNITS
take 1000 G's at 1500 deg. F.

XV-1 Convertiplane in history-making flight ... HASTELLOY alloy X sheet was dished and welded to form the shell of the jet units mounted to the tips of the three rotor blades.

Mounted to the tips of the rotor blades of a new type aircraft are small pressure jet engines encased in shells of HASTELLOY alloy X. In flight, these jet units are subjected to extremes in stress and heat. HASTELLOY alloy X was selected for the shell material because of its high strength at temperatures in excess of 1500 deg. F. and because it is readily formed and welded.

If you have a high temperature or a difficult design problem, contact our nearest sales office, or write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana. Sales Offices in Chicago, Cleveland, Detroit, Houston, Los Angeles, New York and San Francisco.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
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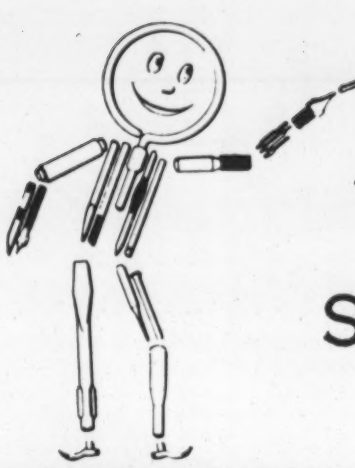
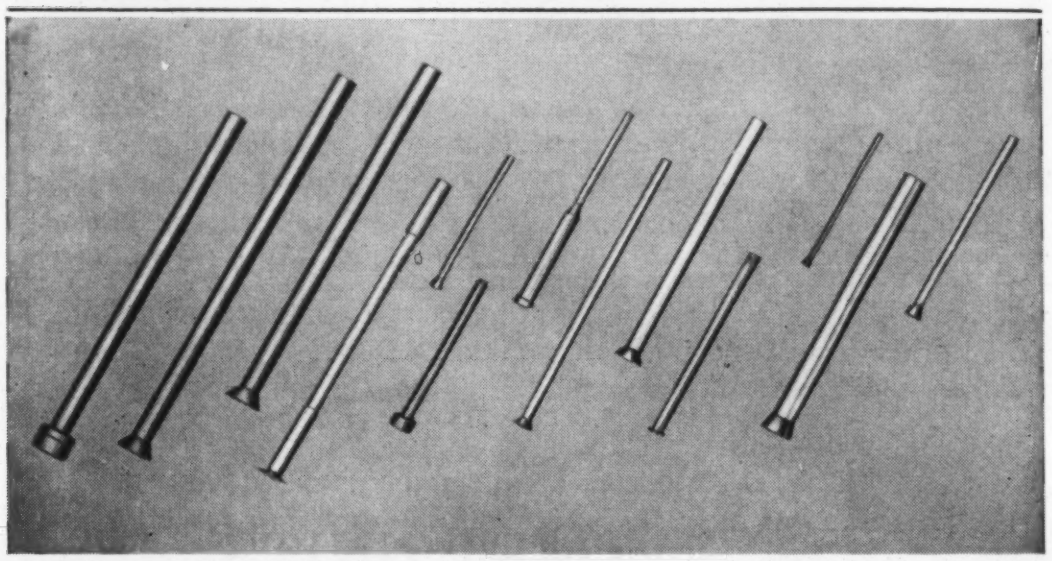


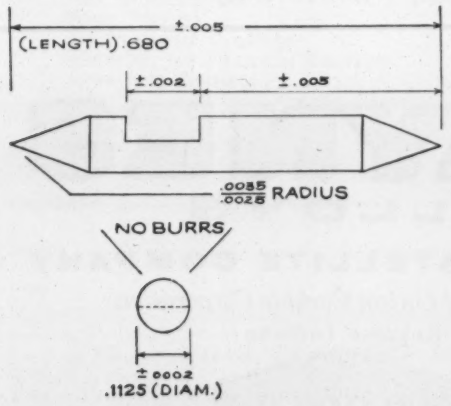
NEWS
from Torrington on
SMALL PRECISION METAL PARTS



Here at Torrington, our "Specialties" machines are constantly at work producing an endless variety of custom-built small precision metal parts. Our engineers help design many of these parts, at the same time developing the most efficient production methods to solve our customers' problems.

For example, one manufacturer recently needed perforating punches with an upset head (see photo above). His own facilities were inadequate for the job . . . specifications called for close body tolerance, grinding, precision heading, hardening and annealing. The punches were to be made from tool steel and produced without flash to allow proper seating. Torrington engineering and production facilities solved his problem.

Another—the volume production of timer parts with low cost a critical factor.



For this job, Torrington developed special high-speed equipment to provide automatic end turning and cross milling in a single operation. The result—a high-quality part produced at low unit cost.

Whatever the part, varying degrees of strength, ductility, hardness, toughness, magnetic or nonmagnetic properties are required to give it the exact qualities needed for its particular function. In Torrington's modern laboratories, highly

experienced metallurgists and engineers are employed to insure that each precision metal part is produced by the most efficient process and to the highest standards required for its application. They'll be glad to help you on all metallurgical problems.

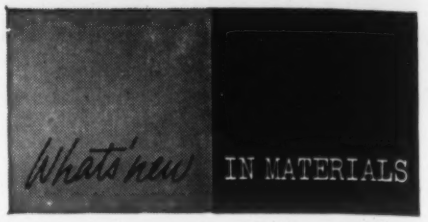
If you have problems involving custom-built small precision metal parts in large quantities, write direct to

The Torrington Company, Specialties Division, 777 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

For more information, turn to Reader Service card, circle No. 492



nate is said to have good thermal insulating properties and good resistance to erosion. Taylor is supplying the material in sheets and tubes.

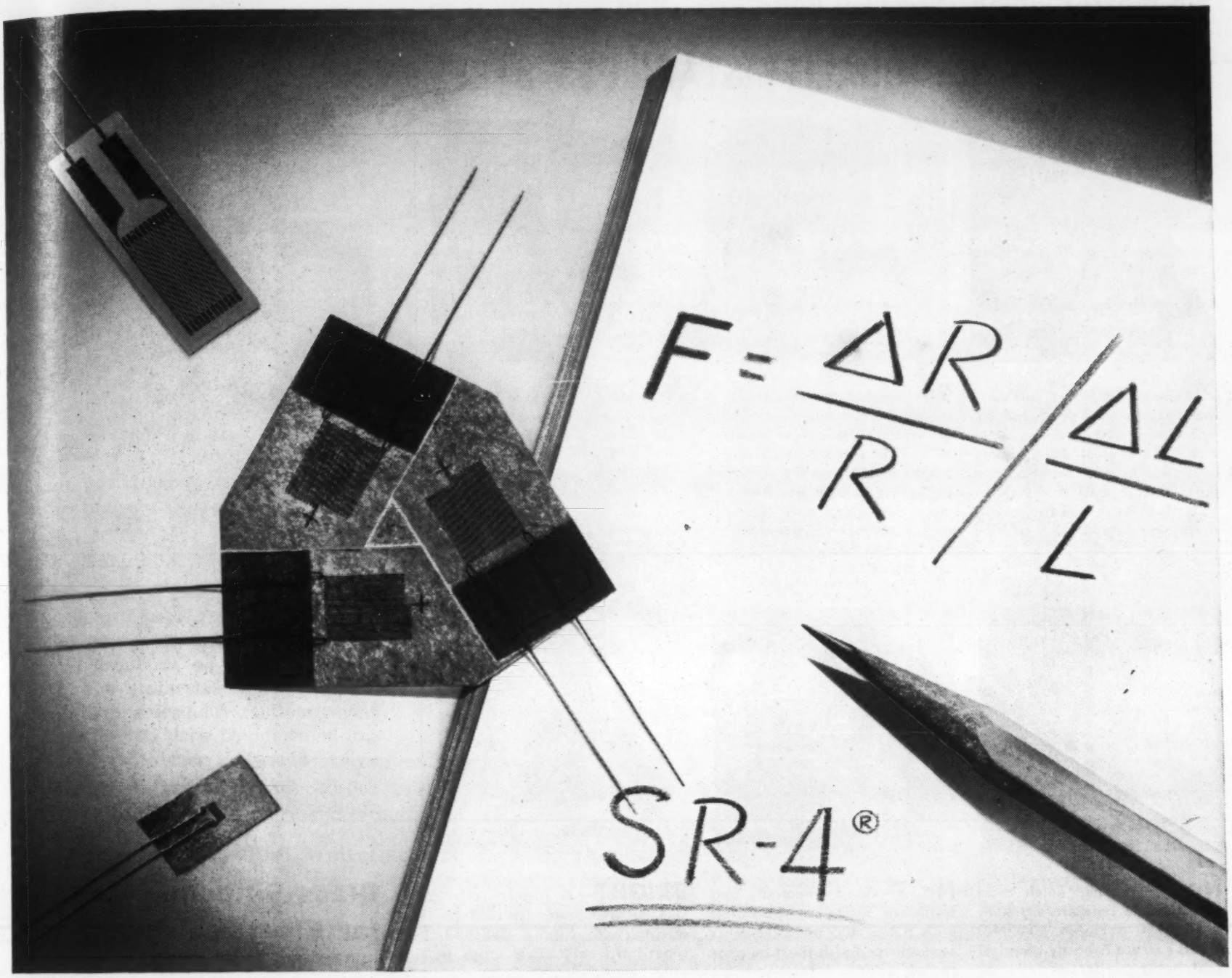
A thermal insulation test, conducted by embedding a thermocouple in the center of a ¼-in. thick laminate exposing the laminate to a temperature of 2000 F, and measuring temperature in the center of the laminate at various intervals, showed that HT-5000 conducted 25% less heat from the surface to the interior after 5 min than other materials tested.

Silicone Sponge Rubber Available as Extrusions

Silicone sponge rubber can now be extruded and calendered into a variety of complex shapes by Stalwart Rubber Co., 165 Northfield Rd., Bedford, Ohio.

Stalwart says it can supply extruded silicone sponge cross sections in long lengths, in continuous lengths,

Aluminum particles—The pair of tweezers shown above hold a particle of coarse granular aluminum, described by the manufacturer, Reynolds Metals Co., 2500 S. 3rd St., Louisville, Ky., as a new metal product that bridges the gap between aluminum shot and aluminum powder. The aluminum particles are expected to find many uses in the chemical field. Two standard sizes of the product are now produced: 300-X, ranging from 0.132 to 0.02 in. dia; and 200-X, ranging from 0.08 to 0.01 in. dia.



Unique research tool . . .

The Ubiquitous Strain Gage

Small size, high accuracy, and amazing versatility have made the SR-4® strain gage an indispensable tool wherever strain measurements are made. For over 15 years this tiny, precision-made bit of paper and metal has been doing a job that nothing else could do.

Data provided by strain gages made possible the lighter, high-strength structural members needed for modern aircraft. They have permitted a close, detailed analysis of wing stresses, propeller vibration, landing gear shock, and many other critical factors in aerodynamic design.

Strain gages have played a major role in developing today's compact, high-powered automobile engine, probing its innermost parts and relaying the story of dynamic stress. They have been used in the structural analysis of buildings, bridges, dams, ships, auto bodies, industrial machinery, and an almost endless list of fabricated parts and structures—even artificial limbs.

Capable of measuring static, dynamic or impact strains under widely divergent ambient conditions, SR-4 strain gages give free rein to the skills and imagination of the scientist, engineer or technician who uses them. A wealth of strain gage data is available. Write to the address below, Dept. 3-J, and ask for Bulletin 4315. Or let us have a B-L-H man call on you.

FIRST in force measurement

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SR-4® Strain Gages • Transducers • Testing Machines

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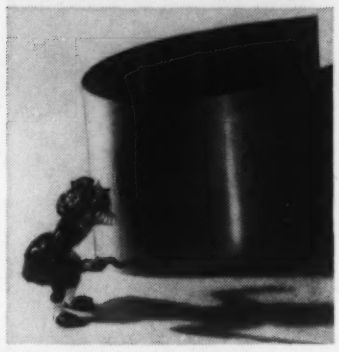
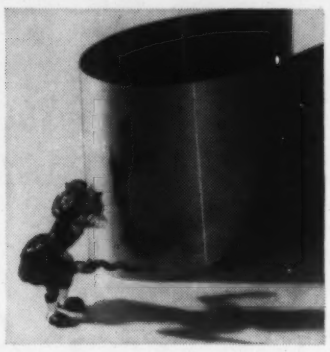
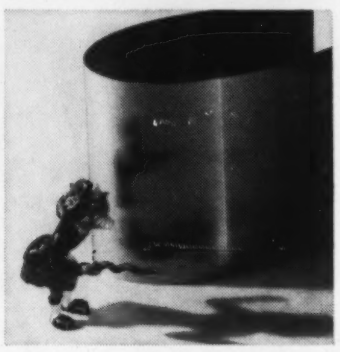
No matter which *FINISH* you like—you can buy it in *MicroRold*® QUALITY STAINLESS STEEL



2D—A silvery white, but non-lustrous, surface produced by annealing and pickling cold reduced material. Steel sheets and strip in this condition are most ductile and the surface holds lubricant well for severe drawing operations.



2B—Steel in the 2D condition which is subsequently rolled on a "skin pass" or temper mill. The surface acquires a bright finish from the polished rolls. This surface is somewhat more dense and hard than 2D and is a better starting surface for later finishing and buffing operations.



No. 3—This surface is made by grinding with a No. 100 abrasive. This surface is smooth but not as reflective as 2B.

No. 4—A finer finish than No. 3 made by grinding with a No. 150 abrasive. Like No. 3, this surface is easily blended with hand grinders after forming, drawing or welding.

No. 7—Good reflectivity and brilliance made by polishing with a No. 400 abrasive. This semi-mirror finish must be protected during fabrication by adhesive paper or strippable plastics lest the finish be marred beyond repair.

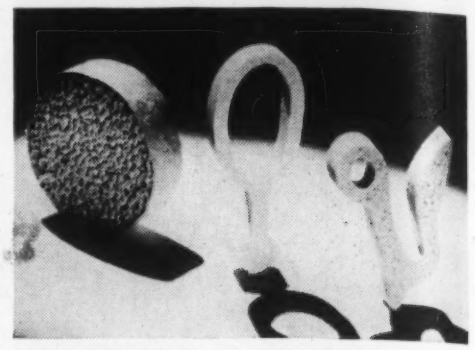
BRIGHT—A highly reflective surface made by cold reducing with highly polished, glass-hard rolls. This finish is only available in Type 430 stainless.

These are our standard surface finishes that are available in types 201, 202, 301, 302, 304 and 430 except Bright which is type 430 exclusively.
These finishes are regularly supplied in sheet and coil form in widths up to 48 inches.
Since Nos. 3, 4, 7 and 430 Bright are smooth reflective surfaces, they are not recommended for severe drawing without special precautions as the mill finish may be marred. Applications such as dairy machinery, kitchen and restaurant equipment and architectural decorative work require only local forming, so these highly polished surfaces are not greatly disturbed. All mill polished sheets are carefully packed to avoid handling imperfections. Protective adhesive paper can be specified by the buyer when needed.
For specific information on recommended surface characteristics for a particular stainless steel sheet and strip application, address your request to our Product Development Dept.

WASHINGTON STEEL CORPORATION

Producers of Stainless Sheet and Strip Exclusively **10-F Woodland Ave., Washington, Pa.**

For more information, turn to Reader Service card, circle No. 488



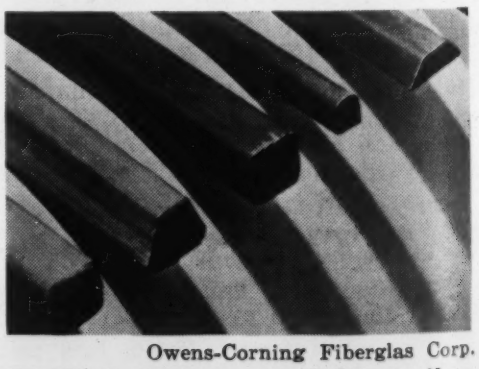
Typical shapes *produced by a new silicone sponge extruding and calendering technique.*

and in coils and rolls to close dimensional tolerances. Sheets of silicone sponge measuring up to 36 in. in width can also be produced by the company's new extruding and calendering method. The calendered sheets can be combined with Orlon, Dacron, nylon, fiberglass and other heat resisting materials for a variety of applications.

Glass-Silicone Rods for Electrical Insulation

Fiberglass-reinforced silicone rods, developed primarily for electrical insulation, are now available in round, square and rectangular shapes in any size or length from Pittsburgh Electrical Insulation Co., Inc., 3000 Bigelow Blvd, Pittsburgh. The rods are manufactured by extruding them twice.

Tests show that the product meets full Class H temperature specifications. Other characteristics: good arc, heat and flame resistance; low dissipation factor; good dimensional stability; close tolerances; good chemical resistance; and good mechanical strength.



Owens-Corning Fiberglas Corp.

Typical shapes *extruded from fiberglass-reinforced silicone.*

it's Wolverine Tube

When the products you design and manufacture require tubing, there are many reasons why Wolverine Tube can help you do a better job.

For example, Wolverine manufactures a complete product line. You can specify copper, brass or aluminum tube in prime surface form or with integral fins (Wolverine Trufin®) to boost heat transfer performance. The latter is also available in electric-welded steel.

To increase inventory flexibility, Wolverine manufactures long-length, bunch-type coils, and for continuous feeding of automatic equipment, Wolverine produces coils in level wound long-length form.

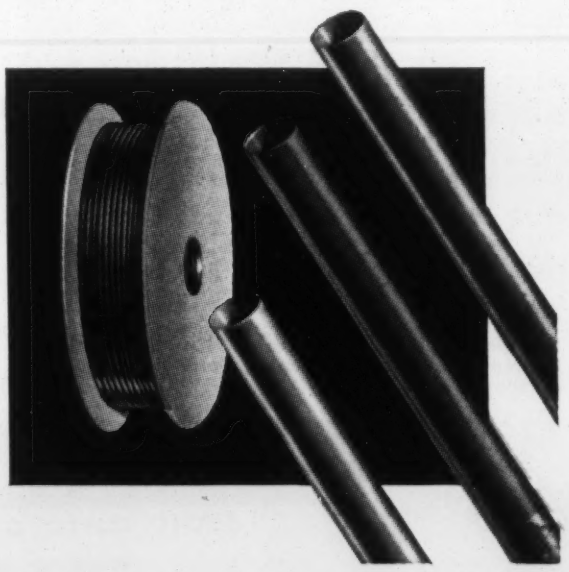
If it's a fabricated tubular part you require Wolverine maintains complete facilities for spinning, coiling, bending, expanding—to name but a few.

If you're considering production flow in your design, Wolverine gives you a boost by packaging its products to meet your production line requirements.

To help you solve special problems concerning tubing Wolverine maintains an extensive Field Engineering Service—a staff of highly skilled tubing technicians whose services are yours without charge.

You can rely, too, on the constant and consistent quality of Wolverine tubing. Produced the Tubemanship way it embraces sound engineering, constant research and rigid quality control.

If design is your responsibility—and tubing is a requirement—remember that you can make things easier and better by specifying Wolverine. For the complete story write for the Wolverine Tubemanship book.



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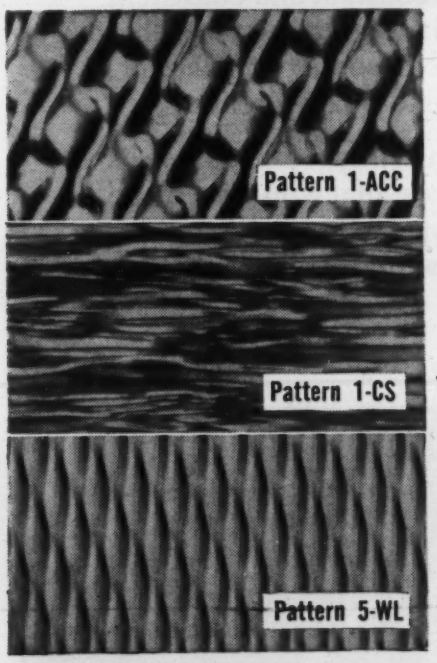
Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario.

For more information, turn to Reader Service card, circle No. 527

Maintenance-Free SERVICEABILITY achieved by Good Design and RIGID-tex® METAL



This pattern in 302 stainless RIGID-tex Metal is used in airplane galleys as shown above.

Wherever surfaces are subject to hard usage, good design calls for RIGID-tex Metal. Its patterned texture presents a mar-resistant finish that hides scratches and scuff marks, retaining the original sparkling beauty and brilliance without maintenance.

All this . . . plus increased strength, greater rigidity, higher impact strength — fits RIGID-tex Metal into almost any product. There are more than 40 standard patterns from which to choose . . . in any metal . . . any color. RIGID-tex Metal is a challenge and inspiration to the designer. Write for literature and samples today!

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For more information, turn to Reader Service card, circle No. 388

What's new IN MATERIALS

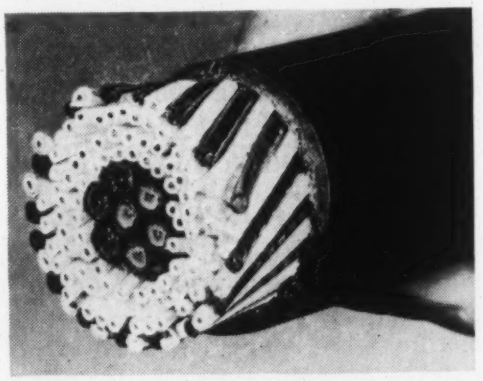
Salt Plus High Heat Cracks Titanium Alloys

Titanium alloys are subjected to stress corrosion cracking when in intimate contact with sodium chloride at temperatures above 500 F, according to Titanium Metallurgical Laboratory, Battelle Memorial Institute, Columbus, Ohio. The Laboratory, in its Report No. 88, gives results taken from an accelerated, hot salt, stress corrosion test run on commercially pure titanium and titanium alloys.

The report also describes a number of methods for increasing the stress corrosion resistance of titanium alloys. Some of these are: 1) shot blasting or stressing of surface to induce compressive surface stresses; 2) cladding; and 3) coating.

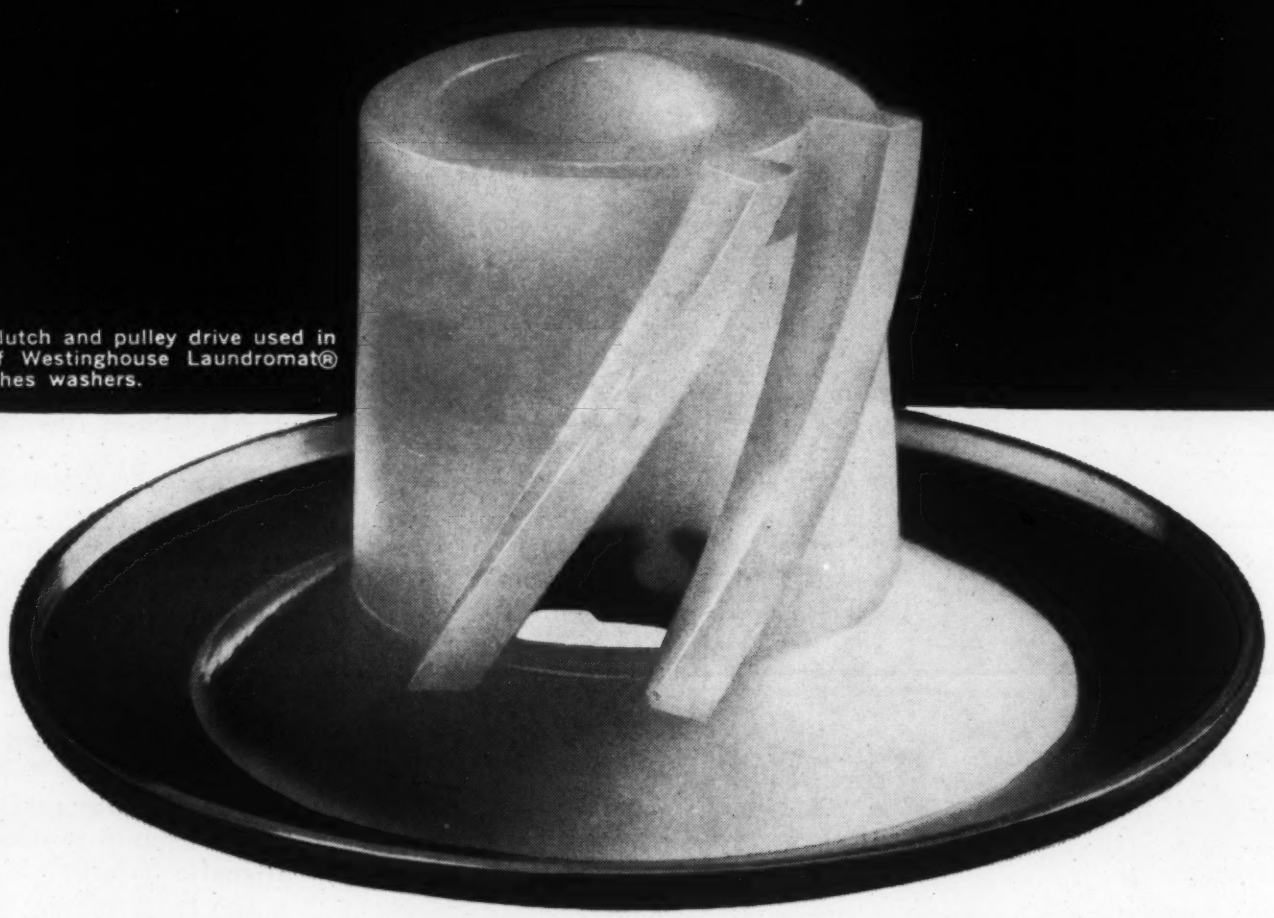
Porous Filter Media

An extremely hard, glass-like porous filter media is now available from Corning Glass Works, New Products Div., Corning, N. Y. in a



Improved cable jacketing—Shown here is an extruded PVC jacketing material for coaxial and other cables. Known as Resinite EP-145 and produced by Borden Chemical Co., 350 Madison Ave., New York 17, the material is reported to have from 11 to 31 times the abrasion resistance of neoprene rubber at various test cycles. The company describes the material as "an improved equivalent of MIL-R-6855, Class II, Grade 60, synthetic rubber." It remains flexible at –100 F, is self-extinguishing, and has good resistance to hot water and hot oils.

EXPENSIVE MACHINING ELIMINATED



Combination clutch and pulley drive used in wide range of Westinghouse Laundromat® automatic clothes washers.

WHEN CHICAGO MOLDED SHOWS HOW NYLON CAN REPLACE METAL . . . AND MAKE A BETTER PART, FOR LESS

By coming up with an imaginative approach, Chicago Molded engineers eliminated a costly machining operation previously needed on this pulley slide when it was made of metal. The solution: a nylon body with a stamped metal insert (sheet steel, flash plated with copper).

This was no mean designing feat. Chicago Molded engineers not only had to produce a less expensive part, but recommend materials and methods that would come up to commercial standards in mass production. This included meeting close tolerances on both the internal diameter of the shaft and the slot — not easy to mold on a multiple contour shape. Another complicating factor was injection-molding around a metal insert.

Working with the Westinghouse Laundromat engineering group, Chicago Molded also came up with a versatile, flash-free mold that could be used to make two different pulley slides. This is necessary because there are *two* slide types, each with a different helical pitch (24° right and 14° left). What they did was design a multiple cavity mold that permits simultaneous production of *both types.* The secret: removable sections in the mold for changing the pitch.

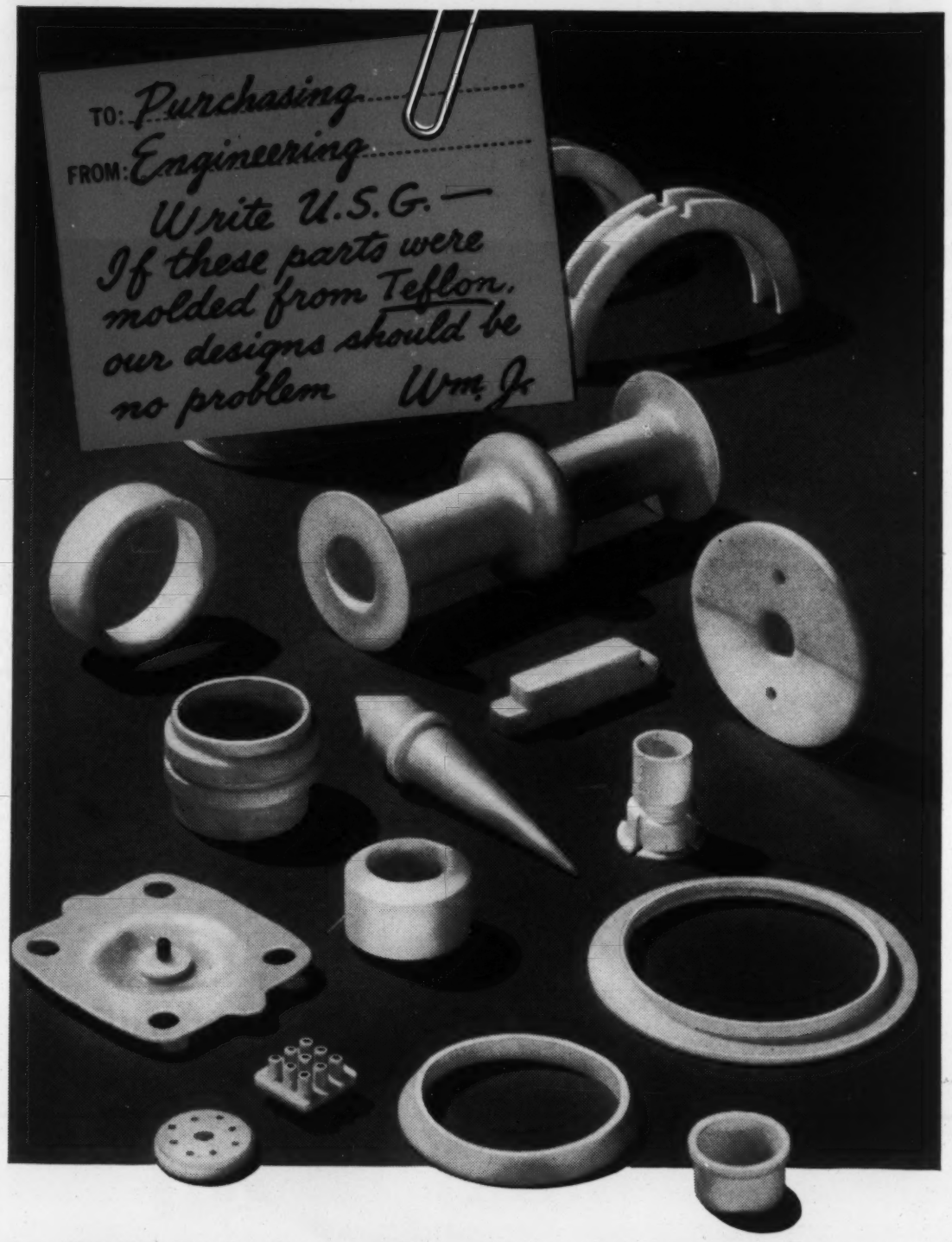
The success of this design illustrates the *cost-cutting* results you get by having Chicago Molded engineers work with your people in the blueprint stages. In suggesting materials and modifications — as well as in designing molds — they can, as they did for Westinghouse, make a better product at lower cost. Perhaps that's why 66% of Chicago Molded's business comes from firms served for over 25 years.

Write today for a free subscription to Plastics Progress, Chicago Molded's data-packed magazine on up-to-date developments in plastics.

CHICAGO MOLDED
PRODUCTS CORPORATION
1026 North Kolmar Avenue, Chicago 2, Illinois

See you at the Plastics Exposition—Booth 615.

For more information, turn to Reader Service card, circle No. 365



Never underestimate the molding possibilities of TEFLON*, in the hands of United States Gasket.

True, it is probably the most difficult of all plastics to mold. But U.S.G. specializes in difficult moldings, involving precision tolerances, intricate shapes, inserts, molding around metallic structures, etc.

They are equipped with unusual "know-how" gained as pioneers and leaders in fluorocarbon plastics fabrication, and the most modern specialized facilities and techniques for cold molding and sintering of TEFLON T.F.E., as well as the injection molding of KEL-F† and the new thermoplastic TEFLON F.E.P.

Send us your difficult fluorocarbon molding problems for quotations. And call upon us, too, for your requirements of fluorocarbon and nylon sheets, discs, tape, rods, tubing, bars, cylinders, etc., from the world's largest and most complete stocks.

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United States Gasket Company
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United States Gasket *Plastics Division of* **GARLOCK**

For more information, turn to Reader Service card, circle No. 434

What's new IN MATERIALS

variety of shapes and sizes. Called Porous Material, the filter media is said to have excellent thermal shock resistance, high strength and good chemical resistance.

Primary use of the porous material is liquid filtration. It can also be used for gas diffusion, air purification, burner plates and catalyst supports.

The material is available as disks, tubes, plates, cups and pellets. The disks are supplied in thicknesses up to 1 in. and in diameters up to 4 in. Tubes are supplied in wall thicknesses of ⅛ to ¼ in., in diameters up to 2¾ in., and in lengths up to 18 in.

Rubber-Coated Fabrics Resistant to Sour Gas

Synthetic rubber-coated fabrics suitable as diaphragm materials for fuel pumps and carburetors are now available from E. I. du Pont de Nemours & Co., Fabrics Div., Wilmington 3, Del.

The coated fabrics, designated Fairprene, are said to have excellent resistance to oxidized gasoline, commonly known as "sour gas." The fabrics are also said to have excellent resistance to ozone and to high aromatic fuels.

The materials are offered in four grades: 26-001FO, coated rayon (36 in. wide); 22-005FO, coated nylon (36 in. wide); 21-009FO, coated cotton (41 in. wide); and 22-006FO, coated nylon (41 in. wide).

Other News . . .

Ferrous metals

▸ Stainless steel condenser tubes fabricated by welding from types 316 and 304 stainless steel strip are now available from Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 20, Conn. The tubes are produced to ASTM specifications A-249 and A-269.

▸ Large vinyl-to-steel sheets (32 x 144 in.) are being marketed by American Nickeloid Co., 2nd & West Sts., Peru, Ill. The company is also marketing a new preplated steel called C-grade in finishes of chromium, nickel and copper. The pre-

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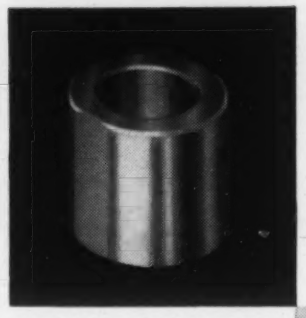

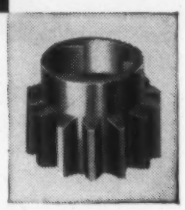

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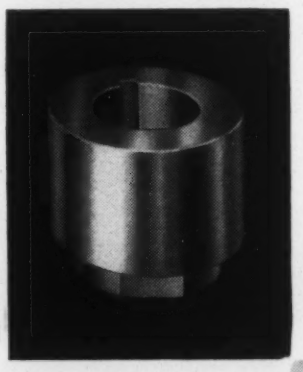
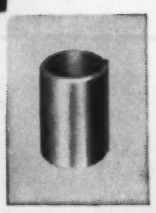
A wide range of stock sizes of Bunting Cast Bronze and Sintered Powdered Bronze self-lubricating, plain and flange bearings, thrust bearings and bars are available from Bunting distributors everywhere in America.





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For more information, turn to Reader Service card, circle No. 465

What's new IN MATERIALS

plated steel is available in sheets 24 x 96 in., in coils to 24 in. wide, and in flat strips ¼ in. or wider up to 96 in. long.

Nonferrous metals

▸ Zirconium strip rolled as thin as 0.0008 in. is supplied in production lot quantities by American Silver Co., Inc., 36-07 Prince St., Flushing 54, N. Y. for use in miniature flash bulbs.

▸ Cadmium - silver - clad phosphor bronze strip is now being produced by American Silver Co., 36-07 Prince St., Flushing 54, N. Y. The clad bronze strip is expected to find use in the manufacture of electrical contact springs.

▸ Dysprosium metal, one of the rare earths, is being produced in commercial quantities by Research Chemicals, Inc., 170 W. Providencia St., Burbank, Calif. Purities range from 98 to 99%. The material is available in lump and ingot form in gram and pound lots.

▸ Teflon-insulated OFHC copper wire and cable is marketed by Aero-Marine Development Corp., 110 Summit Ave., Chatham, N. J. The insulated wire is recommended for electronic devices and aircraft.

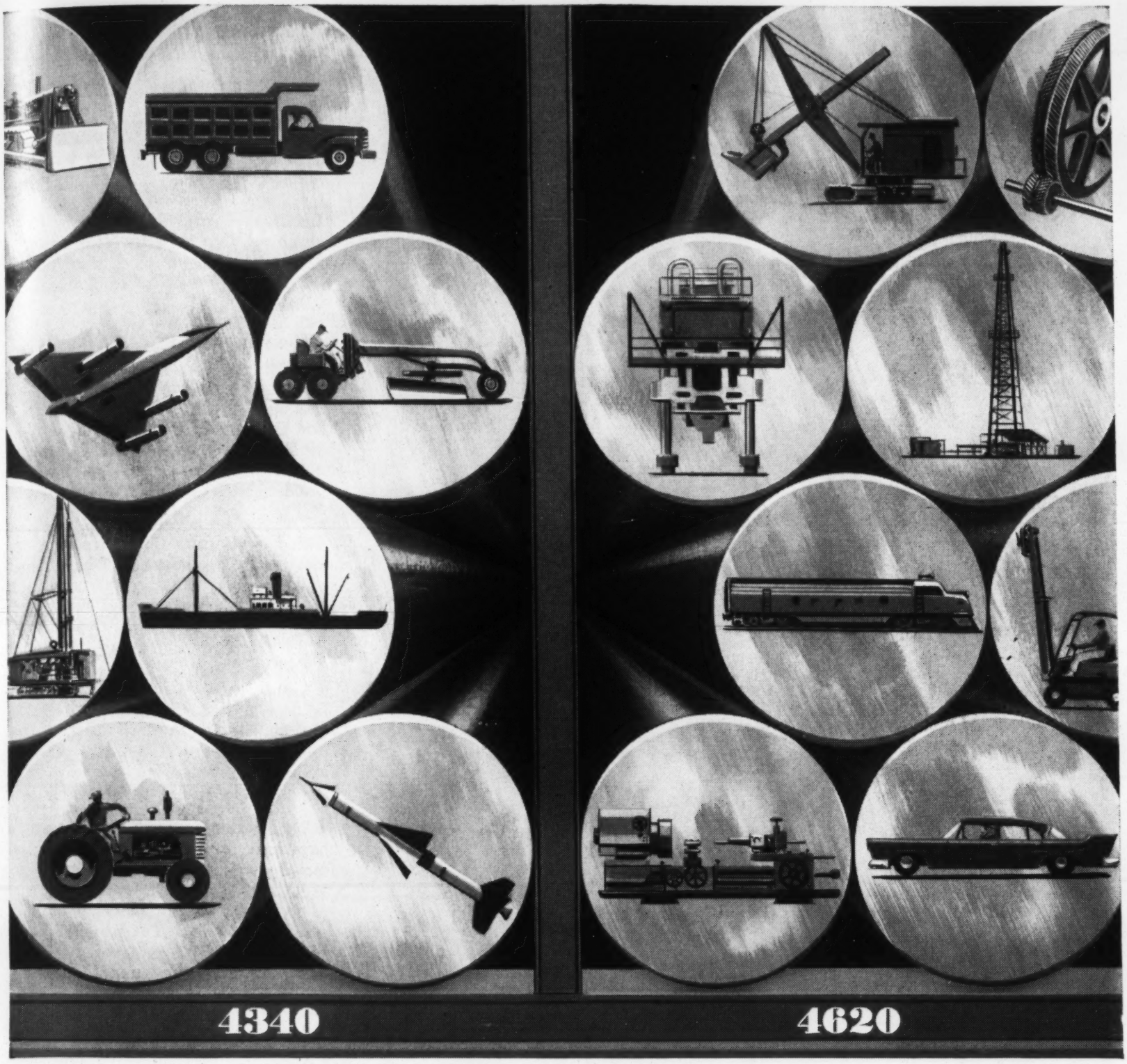
▸ An aluminum alloy, designated X-8001, will be used as a protective jacket for fuel elements in a nuclear reactor now being built in Idaho. Developed by Argonne National Laboratory, P. O. Box 299, Lemont, Ill., the alloy was made by adding small amounts of nickel to aluminum 1100.

Plastics and rubber

▸ A high impact polystyrene sheet in widths up to 60 in. is now available from Auburn Plastics, Inc., Auburn, N. Y. The sheet can be custom extruded up to 3/16 in. thick in any length, according to the producer.

▸ A "pure white" polyethylene plastics pipe has been introduced by H. K. Porter Co., Inc., Quaker Rubber Div., Tacony & Comly Sts., Philadelphia 24, for transporting water and other liquids for human consumption. The pipe is being sold under the name of Puritan White Core.

▸ Tissue-thin foam rubber, available in such grades as oil resistant, reinforced, firm, medium and soft (with open or closed cells), is in commercial production at Otarion



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4340 THROUGH-HARDENING

4340 stands alone among medium carbon steels in its ability to provide maximum strength, ductility, toughness and resistance to fatigue in parts of medium to heavy cross section.

4620 CARBURIZING

4620 is a carburizing type that has consistently proved itself the ideal steel for a wide variety of carburized parts. 4620 is easy to carburize and has a minimum tendency toward distortion in heat treatment.

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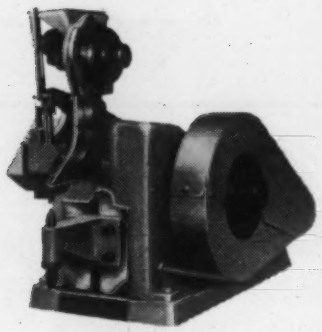
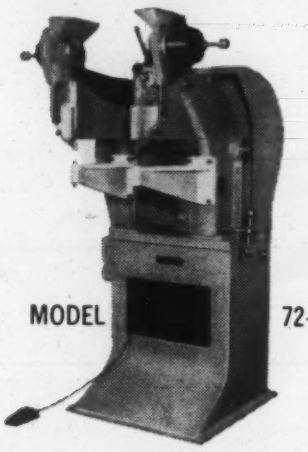
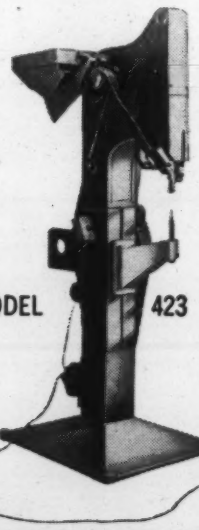


MODEL 52



MODEL 72-DP



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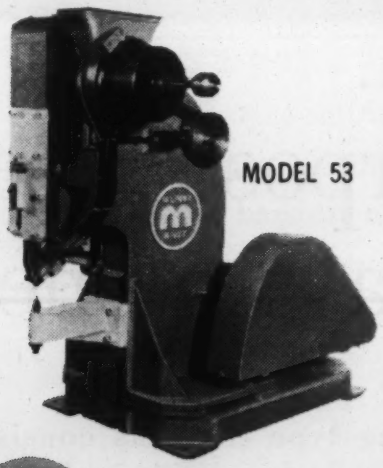

MODEL 53

MODEL 250

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For more information, turn to Reader Service card, circle No. 457

What's new IN MATERIALS

Listener Corp., Scarborough Park, Ossining, N. Y. The foam rubber is supplied in strips 1 in. wide by 24 in. long and in thicknesses of 0.025 in.

Other nonmetallics

▸ An improved activated carbon for use as a catalyst support material has been developed by National Carbon Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. Designated CXC 4/6, the material is supplied as 3/16-in. dia pellets.

▸ Plastics-coated all wool felt is produced by Felters Co., 210 South St., Boston 11. Three grades of the material, called PlastiFelts, are now available; they are coated with nylon, polyethylene and TFE, respectively.

Finishes

▸ A bronze-free gold coating is marketed by Bee Chemical Co., 12933 S. Stony Island Ave., Chicago 33 for application over metals, plastics, glass and wood. The company says the finish does not tarnish or stain.

▸ A new wrinkle finish designed as a base coat for vacuum metallizing on metal stampings and castings has been introduced by Bee Chemical Co., Logo Div., 12933 S. Stony Island Ave., Chicago 33. The product, Logo Wrinkle EA-616, requires a 30-min bake at 325 F to cure to a hard, durable state.

Joining materials

▸ A rubber-base adhesive has been developed for bonding latex and polyurethane foams. Called Bondmaster R275 and available from Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J., the adhesive is quick drying and fast grabbing.

▸ A sealing material that is said to have excellent resistance to freezing and thawing is the latest product from Presstite-Keystone Engineering Products Co., Div. of American-Marietta Co., 39th & Chouteau Sts., St. Louis. The material, called Wat-R-Bar, can be used to form an airtight seal between similar and dissimilar materials.

Testing equipment

▸ A machine capable of performing mechanical tests at a temperature of 3000 F is now commercially available from Marquardt Aircraft Co., Van Nuys, Calif. The machine can perform tensile, fatigue, compression and stress-rupture tests.

For more information, turn to Reader Service card, circle No. 401

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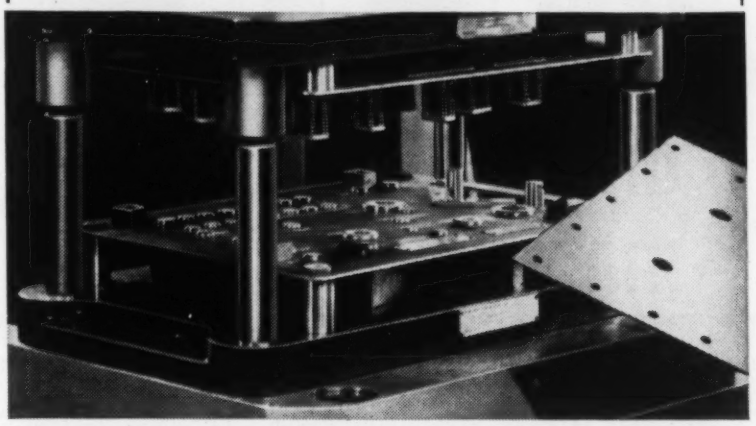

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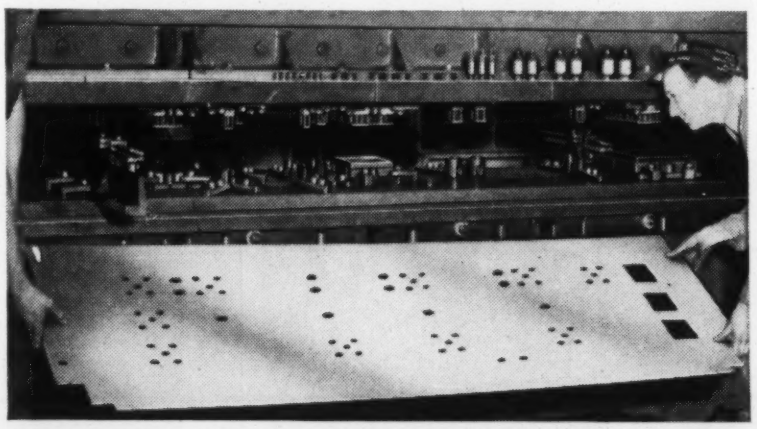

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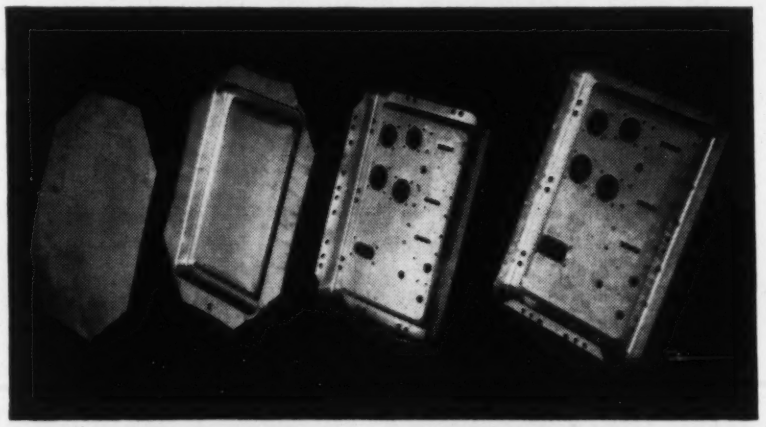

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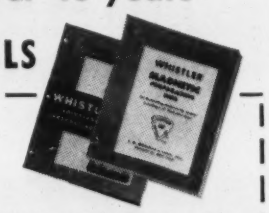

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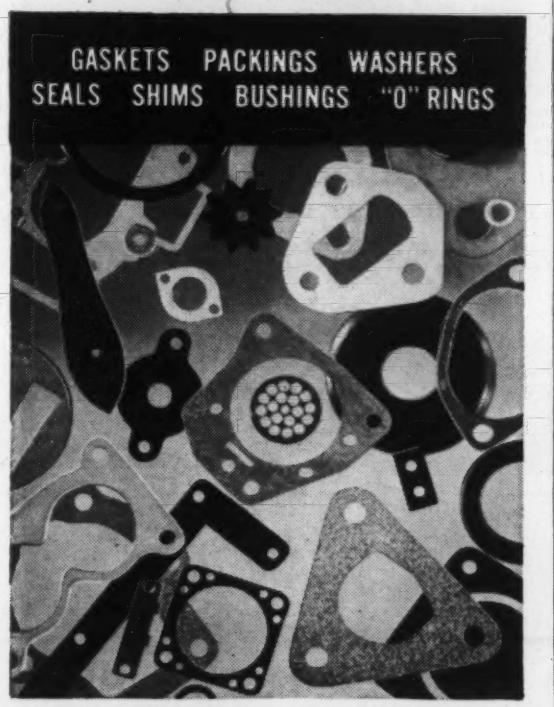

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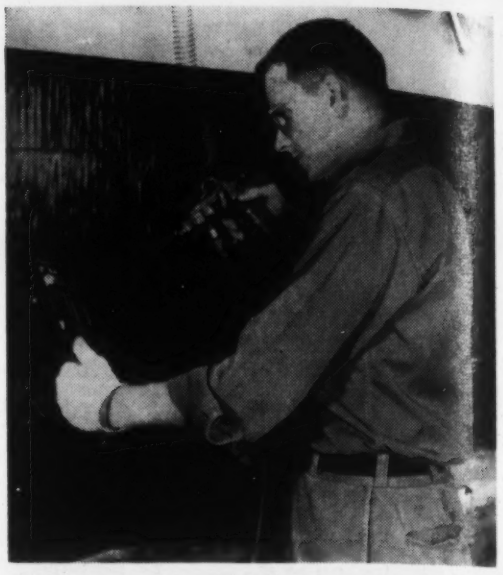
For more information, circle No. 402

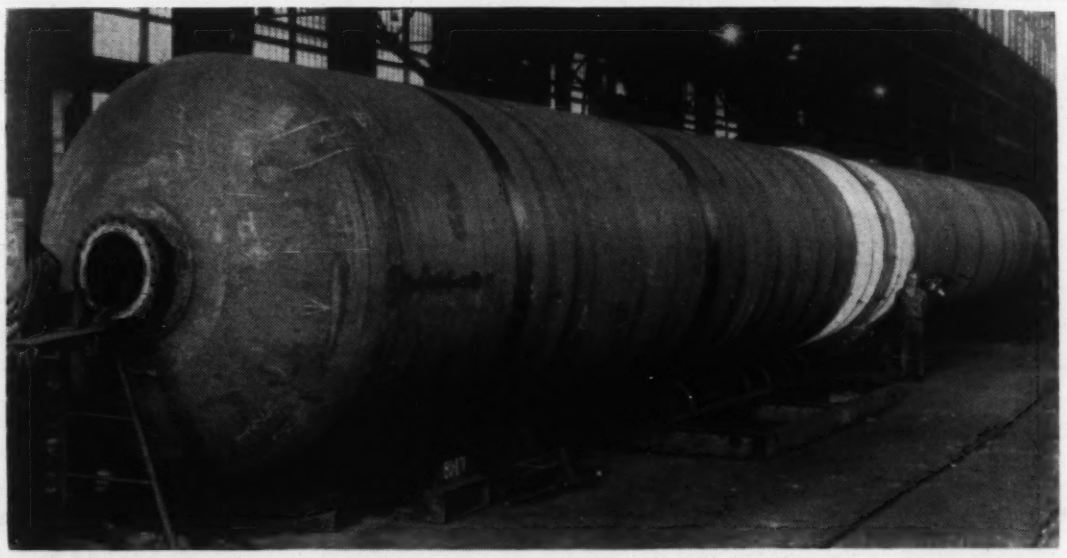
MATERIALS AT WORK

Epoxy—cont'd from p 12

equal advantage for such things as glass, wood, other plastics and metals.



***Coating is easily applied** with spray gun.*



***Stress relieving** welded joint of huge tank was accomplished with chromium-nickel electrical resistance heating coils.*

Large Tank Stress Relieved with Wire

A chromium-nickel electrical resistance heating wire covered with ceramic insulating beads has solved the problem of stress relieving the weld joining two halves of a 10-ft-dia, 114-ft-long steel storage tank.

According to Arcos Corp., the two halves of the tank were stress relieved in conventional heat treating furnaces. However, the furnaces were too small to accommodate the completed tank. The job was done by wrapping several lengths of Heat-O-Coil (resistance wire covered with ceramic insulating beads) around the outside diameter of the tank and hooking the two ends to a d.c. generator. Four thermocouples were spaced 90 deg apart and tack welded lightly to the inside of the weld seam. Thermocouple leads were brought out through one of the tank nozzles and attached to equipment used to record data.

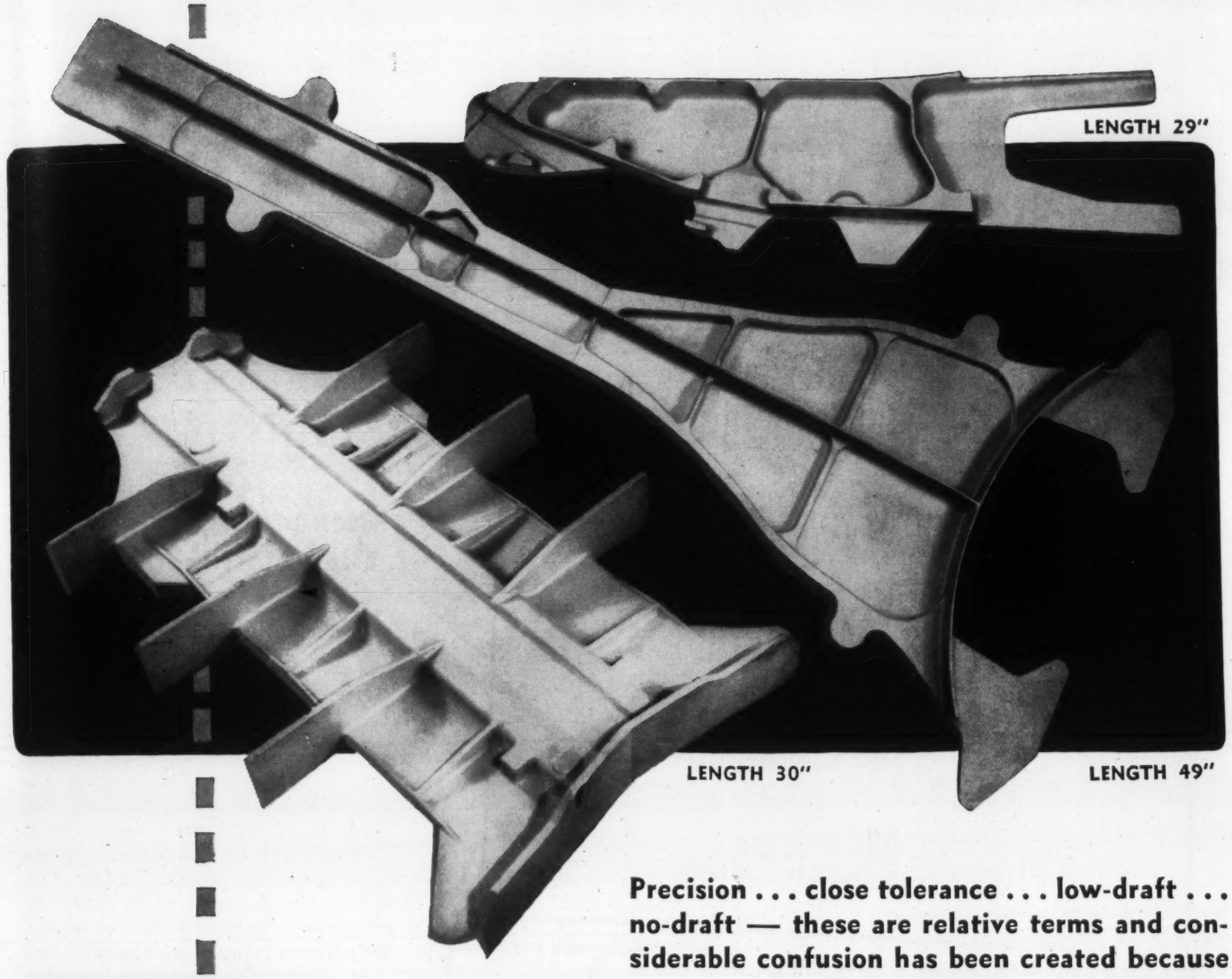
To control the heating and cooling rate, the weld area was "sandwiched" between two blankets of insulation, each consisting of two layers of corrugated asbestos paper covered with a 3-in. thick blanket of wire-meshed rock wool.

The heating cycle was initiated by applying 240 v across the heating coil terminals, causing the temperature to increase approximately 400° F per hr. The temperature was maintained at 1100 F for about an hour and the power was turned off. The insulation retained enough heat to maintain the desired cooling rate.

According to Arcos, the total cost of obtaining what is said to be a "superior stress relief" was less than 1/10 that of stress relieving by induction heating.

(more Materials at Work on p 194)

PRECISION FORGINGS By WYMAN-GORDON



Precision . . . close tolerance . . . low-draft . . . no-draft — these are relative terms and considerable confusion has been created because they have been loosely used. Close tolerances on large forgings have been pioneered by Wyman-Gordon over the years. The degree of precision which is practical now becomes a question of economics.

The forgings illustrated are typical of Wyman-Gordon close tolerance forgings that have been produced in quantity. In solving problems of tolerances, design and metallurgical quality, there is no substitute for Wyman-Gordon experience.

WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

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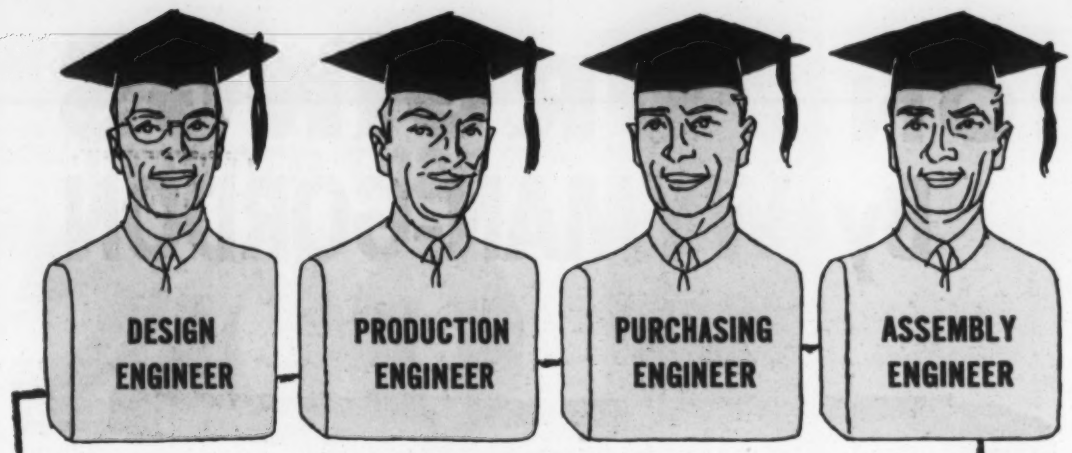

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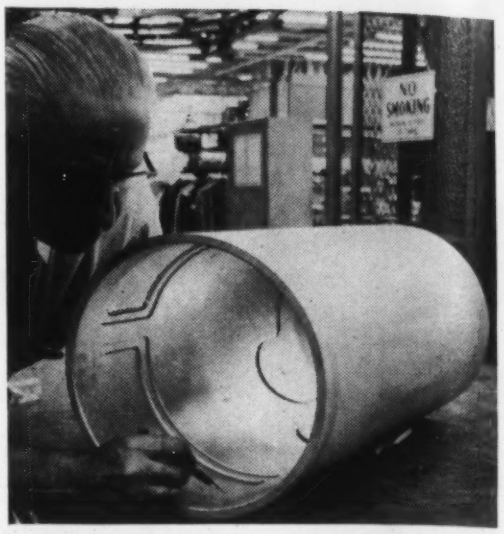


***Etched missile component** is checked for accuracy.*

Etched Part Costs Less Than Machined Part

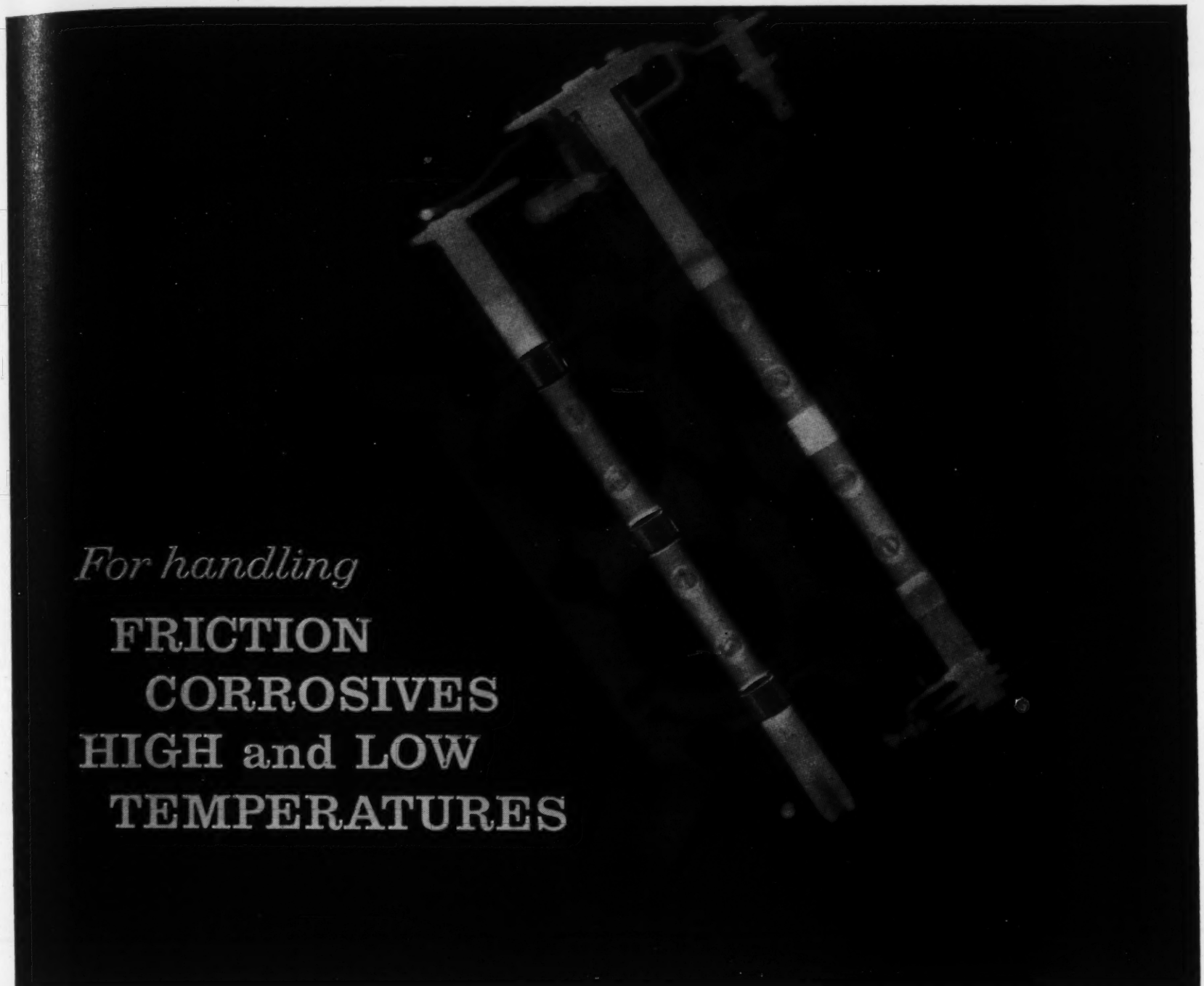
Substantial savings in fabrication and tooling costs have resulted from the switch from machining to chemical milling in the production of Terrier guided missile components. According to Convair Div., General Dynamics Corp., chemical milling not only saves time and money, but is "ideally suited to the difficult contour relief problems" (see photo).

To produce the part shown in the accompanying photo, Convair first masks the material to be etched by alternately dipping it in a compound and heat drying four times. After final drying, the masking is trimmed and stripped away from areas that are to be etched. After etching, the part is rinsed and brightened in a mild etchant.

Jet Engine Bearings Protected by Silicone

The jet engine bearings shown in the accompanying photo were operated at 7100 rpm for 50 hr under a 5000-lb axial load and suffered no visible damage whatsoever. Reason: they were lubricated with a silicone fluid.

According to General Electric Co., this test was one of a series presently being conducted on silicone lubricating fluids. Indications thus far are that these lubricants "per-



X-RAY photo shows use of a Du Pont TEFLON TFE resin as sleeve bearings for auto carburetors . . . bearing costs are drastically reduced.

Here's why bearings of TFE-fluorocarbon resins may be your solution

Bearings of TFE-fluorocarbon resins are "self-lubricating". Even the best lubricants used on metal rarely provide a coefficient of friction as low as 0.04, which is readily attained with TFE resins at low velocities. Moreover, TFE resins are among the most chemically inert materials known to science. They are rated for continuous use at temperatures from −450°F. to 500°F.

THAT'S WHY: You can use *dry bearings* of TFE resins where lubrication is difficult or even impossible. They perform unharmed in contact with hot, corrosive liquids . . . keep products free of contamination by eliminating oil and grease. In liquid oxygen service (-321°F.), bearings of TFE resins offer the same low friction they do at room temperatures.

In use, the bearings coat revolving shafts with a molecular film of the TFE resin. Thus, any friction is that of the resin against itself. Bearings of TFE resins can be tailored for high loads, high velocities or high wear-resistance by the use of reinforced constructions.

Discover how you can improve your products and processes with bearings of Du Pont TFE-fluorocarbon resins. For product and design information see your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room ME 2524, Nemours Building, Wilmington 98, Delaware.**

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.

• A heavy duty TFE resin construction replaced a super-alloy in rod-ends of aircraft controls. Lined sockets withstand operating loads as high as 60,000 psi without lubrication. Break-away and running friction are less than half that of a greased bearing.

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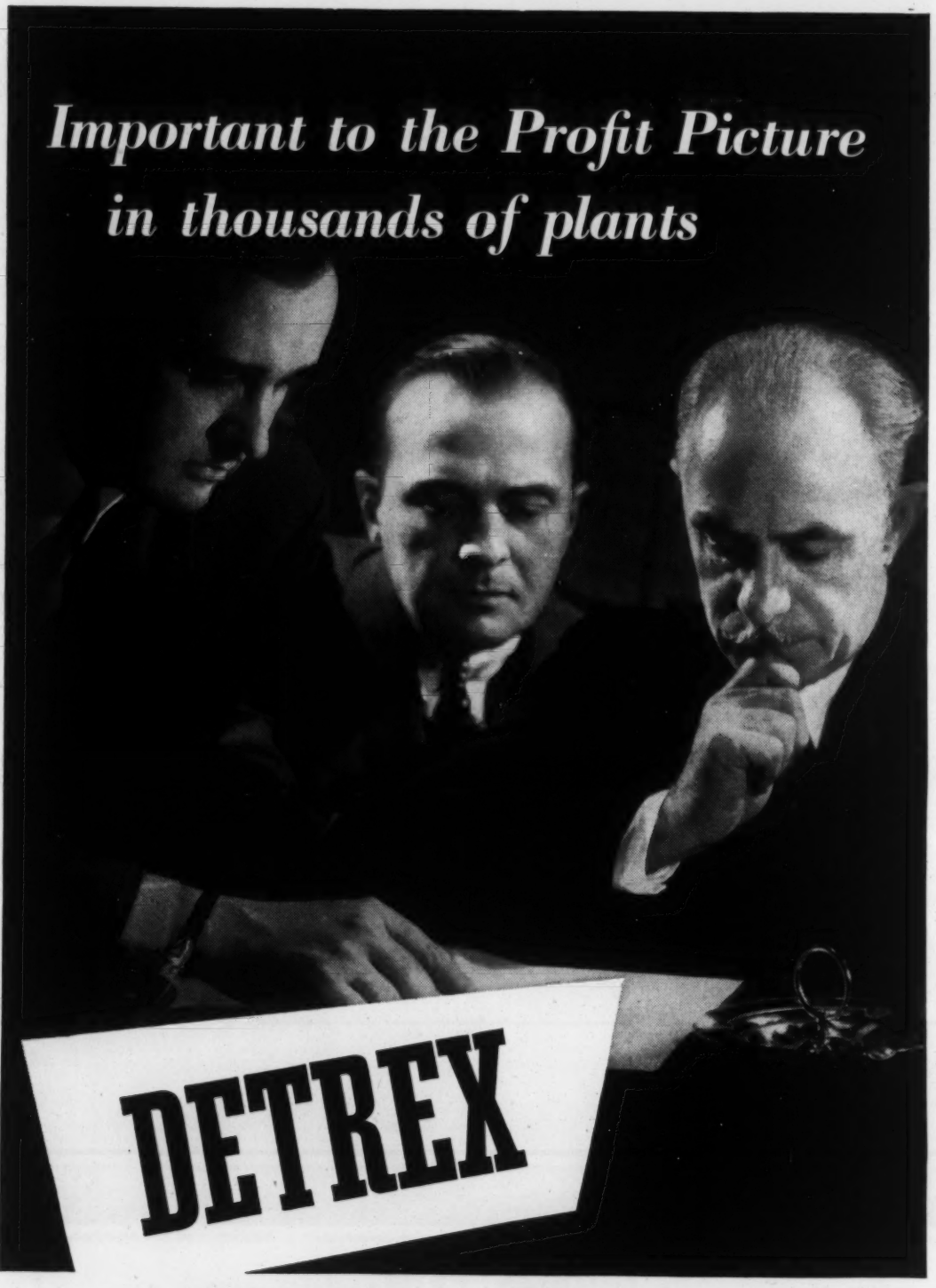

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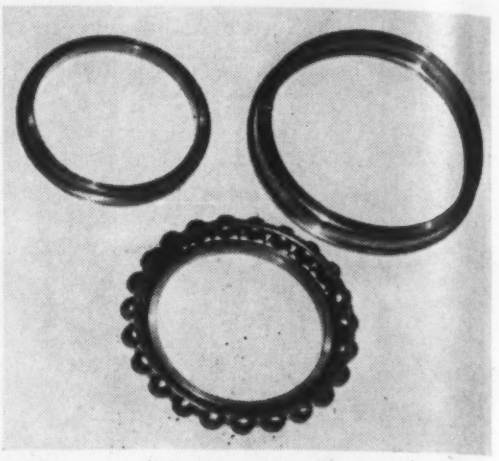


Silicone lubricating fluid *protects these bearings at temperatures as high as 700 F.*

form better in the 500-700 F range than any other known fluids." They are characterized by exceptional thermal and oxidative stability and are expected to find wide usage as high temperature lubricants for jet engines. (For further technical details on this and other silicone lubricants, see M/DE, Apr '58, p 124.)

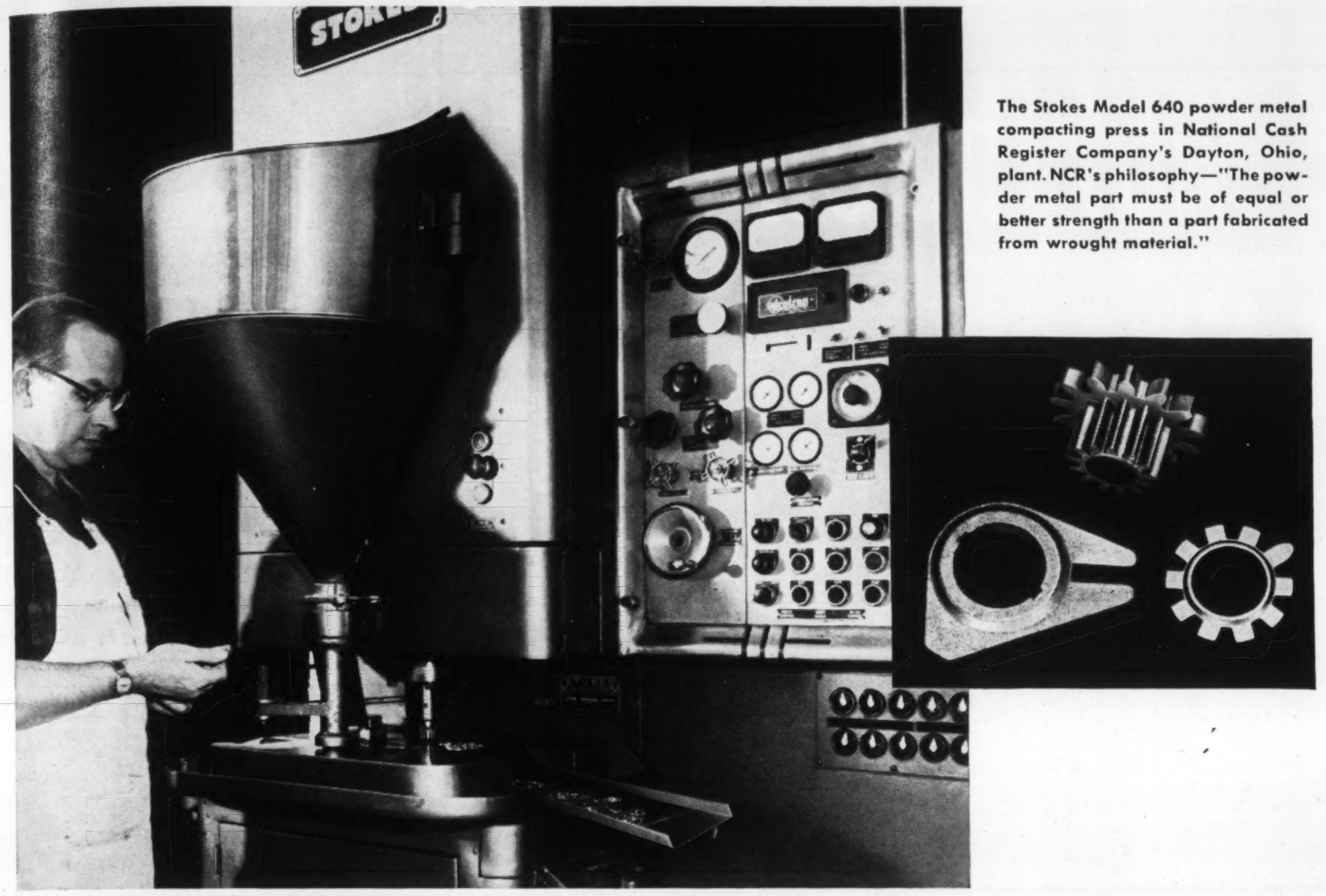
Extruded Steel Shape Replaces Milled Bar

Production of swing-out arms for the cylinders of target revolvers has been simplified and speeded up by as much as six times as a result of the switch from milled bar stock to extruded shapes. In addition, production cost has been reduced by about 8%.

The finished arm is 7/32 in. wide, except on the outward end where a head 5/8 in. wide is required. According to Jones & Laughlin Steel Corp., the part was originally milled out of 1 3/8-in. lengths of 5/16 x 5/8-in. bar stock. Now the part is made by: 1) cutting 5/8 in. long blanks from a bar extruded to the general con-

STANDARDS ARTICLES REPRINTED

The six-part "Guide to Materials Standards and Specifications" which appeared in M/DE, Mar to Aug '58, is now available as an attractive 24-page reprint, as a result of many requests. Cost: 75¢ each in quantities up to 10; 60¢ each for 10 or more. Order from Reader Service Dept.



The Stokes Model 640 powder metal compacting press in National Cash Register Company's Dayton, Ohio, plant. NCR's philosophy—"The powder metal part must be of equal or better strength than a part fabricated from wrought material."

National Cash Register rings up savings through powder metallurgy...

The Stokes Model 640 50-ton powder metal press, at the Dayton, Ohio, plant of National Cash Register Company, has proved a valuable tool in the production of precision gears and parts for cash registers and accounting machines. In 1957, over 250 different high-density parts were made by powder metallurgy—in early '58, 47 additional parts went into production.

The economic benefits of this process have also been proved. A cost analysis of 54 parts shows substantial savings per year through lower direct labor costs in machining and inspection. More complex parts are continually being introduced—parts with hubs, steps, and thin projections—made possible by press equipment such as the Stokes 640.

The Stokes Model 640 offers up to five press motions with independently adjustable compression, fill and ejection points . . . each with direct reading position indicators calibrated to .001". This set-up versatility is teamed with operating simplicity that enables economical long or short runs, and permits easy re-runs of jobs on which set-up standards have been established.

Investigate the proved potential of powder metal pressing . . . not only for ways to cut costs and save metal over conventional machining, but also for ways to get properties of metals, alloys and mixtures not attainable by other techniques. Ask for a production and economic analysis on your own parts. Stokes' facilities include sample production, punch and die design and fabrication, and operator instruction. Stokes Engineering Advisory Service is ready to serve your powder metallurgy needs, whether large or small.

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

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- √ keeping inventories at a minimum.

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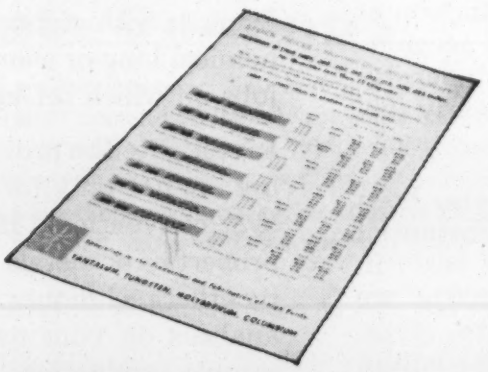
TANTALUM USERS get the same benefits from the Fansteel Tantalum Sheet stock program.

IMMEDIATE	.005"
DELIVERY	.007"
ON THESE	.010"
7 SIZES	.012"
OF DUCTILE	.015"
MOLY "D"	.020"
SHEET	.025"



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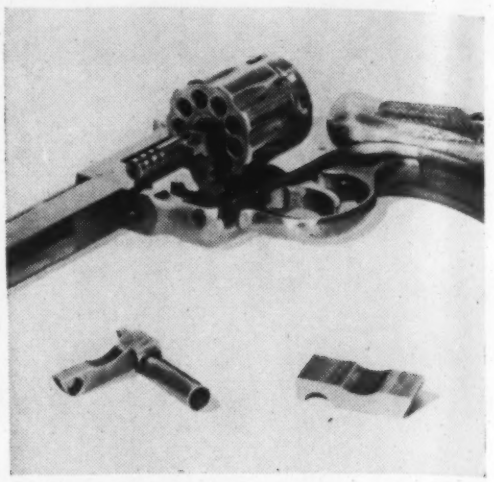
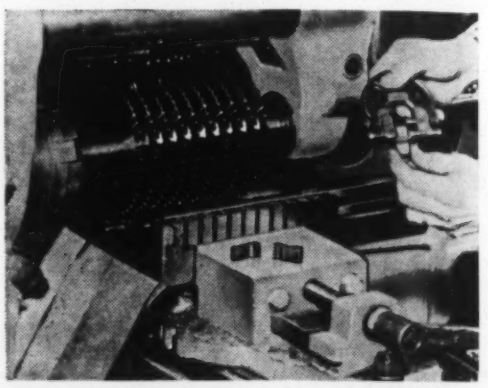


Extruded shape *(right foreground) replaces milled bar stock in production of swing-out arm for revolver cylinders.*



Blanks are cut *10 at a time.*

tour of the finished part, 2) machining the arm to a width of 7/32 in., 3) drilling a hole for the pin on which the arm swings, 4) silver brazing a 5/16-in. dia steel tube on which the cylinder rotates in the circular contour of the head, and 5) milling the desired contour on the head.

Aluminum Ceiling Can Heat or Cool Room

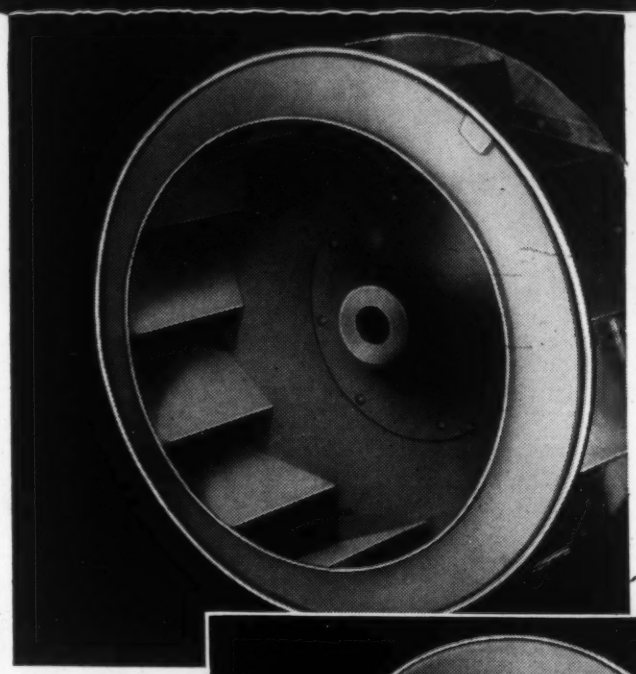
A new type of ceiling installation utilizing perforated panels of enameled aluminum sheet and a layer of insulating material is said to perform three different functions: it can heat, it can cool and it can absorb sound.

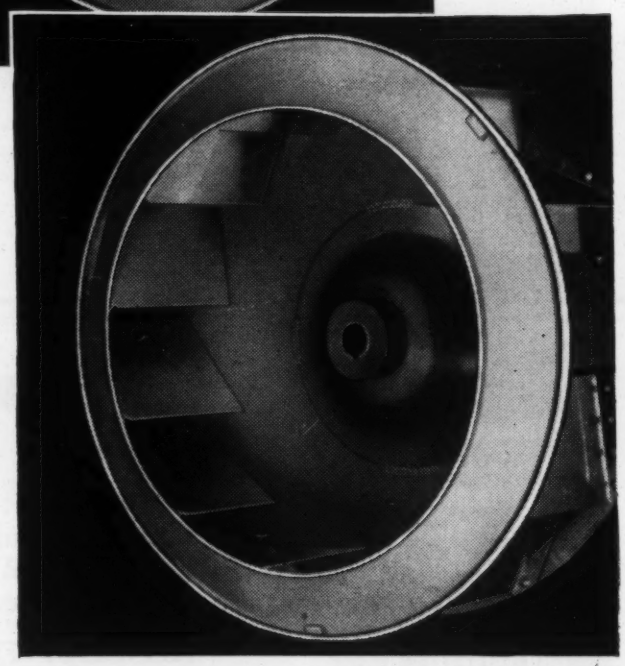
As shown in the accompanying photo, the layer of insulating material is first placed in position and a series of water pipes are installed along the length of the ceiling. Installation of the panels is then ac-

Weldynamics

ARC WELDING AT WORK CUTTING COSTS

Switch from cast iron to welded steel saves 61% on blower hubs





(Top) *Blower rotor with cast iron hub attached by rivets.*

(Bottom) *Same size rotor with welded and spun steel hub attached by intermittent welds.*

Because steel is 3 times stronger, 2½ times more rigid and costs ⅓ as much as cast iron a blower manufacturer was able to cut costs of blower hubs 61%.

Additional advantages of welded steel are:

- 42% lighter permitting use of lighter bearings and shafts
- Higher maximum speeds—no danger of fracture
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PROBLEM: A large zirconium producer needed a material to withstand corrosive gases entering scrubbing towers at +300° F.

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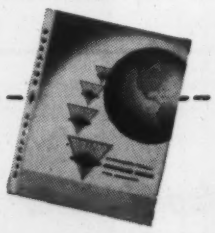

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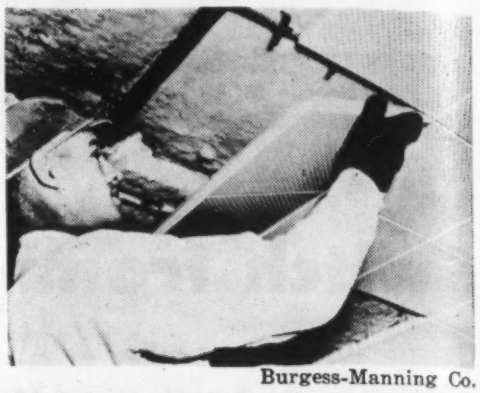
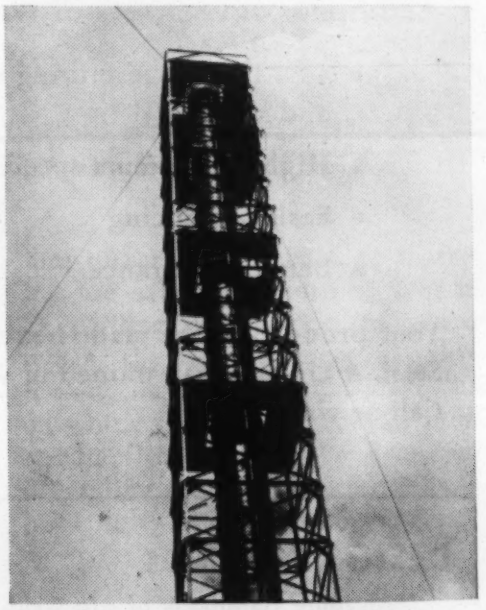


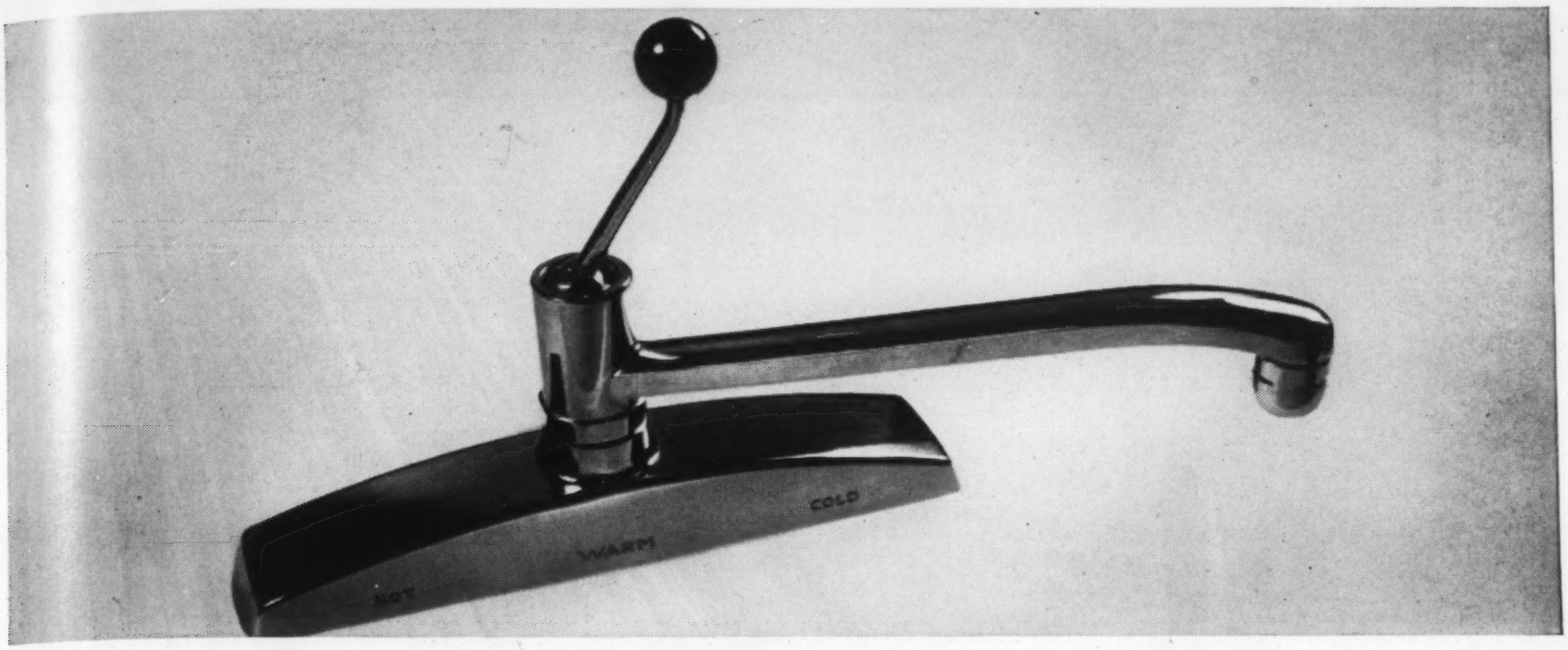
Burgess-Manning Co.
***Aluminum panels** are snapped on.*

complished by merely snapping them into special clamps attached to the water pipes.

Whether the ceiling heats or cools depends on whether the water running through the pipes is hot or cold. The insulating material actually performs two functions: it is both sound absorber and heat reflector.

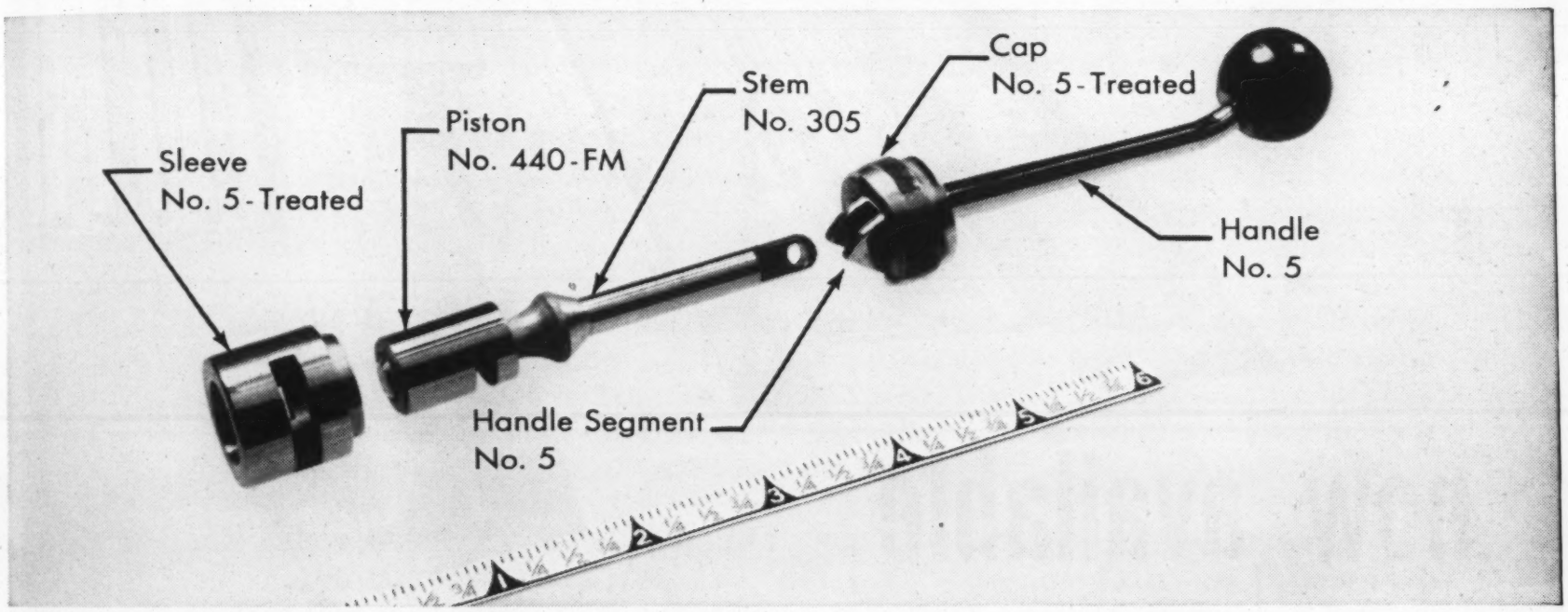


Largest plastics stack—The asbestos-reinforced phenolic fume stack shown above is said to be the largest plastics unit of its type ever installed; it stands 179 ft tall, is 5 ft in dia and weighs 42,000 lb. Produced by Haveg Industries, Inc. for use by Molybdenum Corp. in the production of molybdenum oxide, the stack was originally installed to replace a stainless steel unit which corroded after only eight months as a result of corrosive fumes. The phenolic stack has been in service for over three years without signs of deterioration.



for strength, corrosion resistance and sales appeal

...it had to be Stainless



In this new one-handle mixing faucet all the important working parts are made of wear-resistant, corrosion-proof Carpenter stainless steels. Once you select stainless steel by Carpenter, you can forget about corrosion. You can design for high stresses, disregard maintenance problems, stop worrying about temperature variations and be assured that fabrication will be easy. And you not only get the help of consumer-acceptance of stainless products, but also the long experience of Carpenter. From the lab work through final production, Carpenter staffmen have the knowledge and the data. Call your Carpenter representative for the engineering information on stainless that you need. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

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now available MAMMOTH EXTRUSIONS

Big magnesium and aluminum extrusions produced from Dow's 13,200 ton press

A whole new range of king-size dimensions is now available for design engineers. Dow's new 13,200 ton extrusion press at Madison, Illinois, is producing "special" sizes for quick delivery. These projects include work for aircraft and missiles, automotive, building, and highway construction.

Here's what the big press can do in the way of magnesium and aluminum extrusions to meet your special requirements.

Check this list:

1. **LARGER EXTRUSIONS. Sizes up to a circumscribing circle of 30"**
2. **LONGER EXTRUSIONS. Up to 80 feet in length**
3. **THINNER SECTIONS. Down to 0.125"**
4. **STEPPED EXTRUSIONS. Solid or hollow**
5. **COMBINED HOLLOW EXTRUSION-FORGINGS**

***FOR DESCRIPTIVE LITERATURE** on the big press, contact your nearest Dow sales office, or write The Dow Chemical Company, Midland, Michigan, Dept. MA 1401J-1*

YOU CAN DEPEND ON DOW

For more information, turn to Reader Service Card, circle No. 398

PRICES AND SUPPLY

...AT A GLANCE

NICKEL PRODUCTION HAS BEEN REDUCED an additional 20% by International Nickel Co. of Canada—its third cut this year. The latest cut amounts to more than 4 million pounds per month and brings Inco's annual production rate down to 200 million pounds; the company's 1957 rate was 310 million pounds. Reason for the cut: continued accumulation of unsold nickel in "our hands and the hands of the U. S. Government."

GREATER AVAILABILITY OF GLASS PLATE is in the offing as a result of Pittsburgh Plate Glass Co.'s new $34-million plant. According to Robert F. Barker, vice president, the new plant is geared to produce an estimated 50 million square feet of polished plate glass per year.

PRICES OF POLYVINYL ACETATE EMULSIONS HAVE BEEN REDUCED 5¢ per lb by Shawinigan Resins Corp. The new price is 47¢ per lb for truckload quantities. According to Shawinigan, the price cut was made possible by "manufacturing economies" and increased usage in the adhesives, coatings, synthetic fabrics and building products industries.

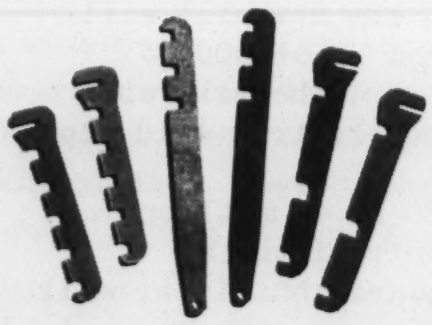
THE FIRST LEGAL BATTLE RESULTING FROM DU PONT'S covering linear polyethylene (see M/DE, Apr '58, p 247) is now going on in the U. S. District Court at Wilmington, Del. Du Pont has filed suit against Phillips Petroleum Co. charging an infringement of the patent. Phillips, presently marketing a linear polyethylene under the tradename Marlex, has stated that Du Pont's patent is "invalid and not infringed."

AVAILABILITY OF STEEL SHEET AND STRIP in the western part of the U. S. will be substantially increased as a result of Kaiser Steel Co.'s recent completion of a new hot strip mill in Fontana, Calif. According to Jack L. Ashby, vice president and general manager, the new mill will virtually double Kaiser's total annual output—from 1,564,000 to 2,933,000 ingot tons. In addition to sheet and strip, the mill will turn out semifinished steel for use in tinplate and electric weld pipe.

POLYPROPYLENE PRODUCTION IN THE U. S. WILL BE INCREASED by 40 million pounds per year as a result of Standard Oil Co.'s entry into the petrochemical plastics field. Humble Oil, a Standard affiliate, will produce the material at a new plant in Texas. Marketing will be handled by Enjay Co., a subsidiary of Standard, through its own facilities and through Spencer Chemical Co. Patents are held by Esso Research & Engineering Corp. and Ziegler catalysts are used.

The next quarterly tabular report on Prices of Materials will appear in the December issue.

"S" is for Signal, Safety and Synthane



Typical pushers, machined from Synthane laminated plastics, used for railway signal relay.

Railroads can't even think in terms of failure. And that is why, among the many working parts that constitute railway signal relays, you find pushers made of Synthane laminated plastics.

These pushers, on which life itself depends, must in the words of one manufacturer have "excellent insulating characteristics—be durable and unchanging," must "not chip, wear and thus leave residual dust or particles which would cause trouble if they should lodge on the electrical contacts."

Synthane has all of these characteristics plus a combination of many other useful properties required for reliable performance. Equally important is the dependability of Synthane, the company, as a source of supply. You are urged to visit us and see for yourself the plant behind Synthane sheets, rods, tubes and fabricated parts—or to discuss this important point with our representative. Meanwhile, write for our new, complete catalog.

SYNTHANE

SYNTHANE CORPORATION, 3 RIVER ROAD, OAKS, PA.

For more information, turn to Reader Service card, circle No. 379

1958 Plastics Show To Be Held in Chicago

The 8th National Plastics Exposition and Annual Conference, sponsored by the Society of the Plastics Industry, Inc., is scheduled to be held Nov 17-21 at Chicago's International Amphitheatre. The theme of both the Exposition and Conference is "Plastics for Profits" and, according to John J. Bachner, chairman of the Exposition Committee, a record attendance is expected.

"In addition to stressing the technical and competitive advantages of plastics from a manufacturing standpoint," Mr. Bachner says, "most of the 200 exhibitors at the Exposition will demonstrate the progress of the industry's research and development programs during the past two years."

According to William T. Cruse, executive vice president of SPI, exhibits at the Exposition "will illustrate how plastics materials and processes, properly applied, contribute to improvement of product quality, performance and maintenance, often at the same or lower costs."

Admission to the Exposition is limited to properly registered representatives of industry, education and government. Tickets may be obtained by writing to SPI, 250 Park Ave., New York, N. Y.

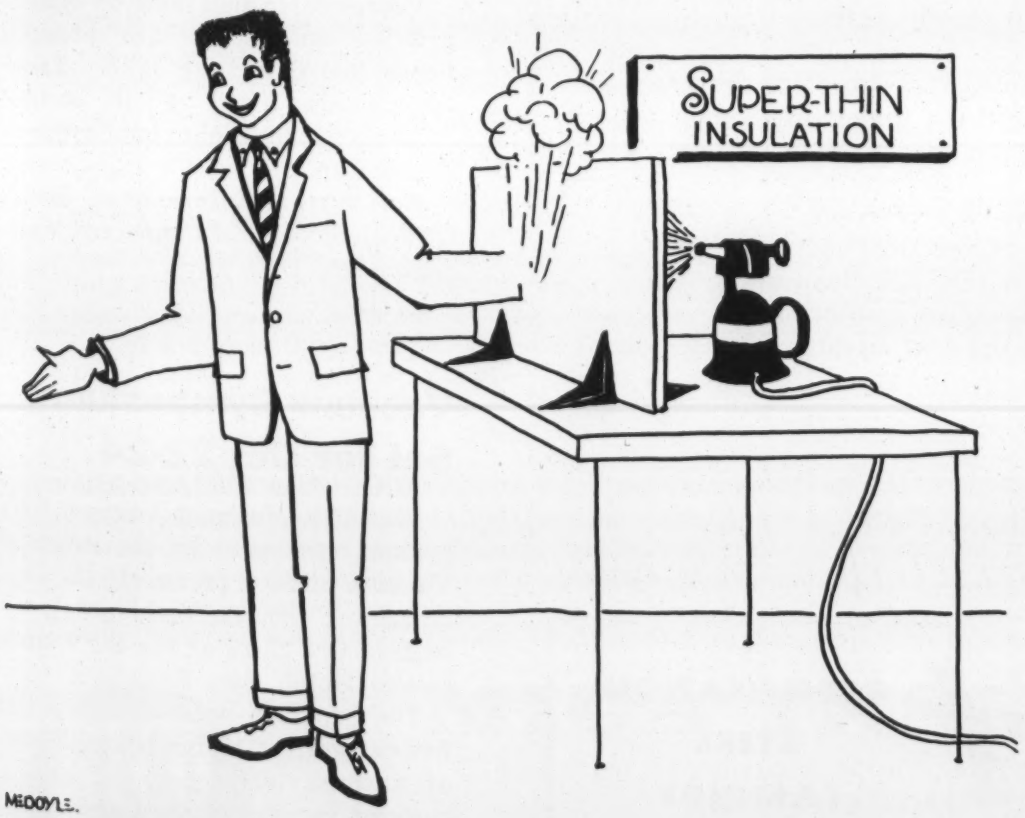
The Annual Conference, to be held at the Hotel Morrison, will consist of panel discussions on: management, costing procedures, design trends, sheet forming, plastics in building, cellular plastics, appliance applications, merchandising and distribution programs, and opportunities.

Some of the papers scheduled for delivery at the Conference include: "Formed Plastics Sheets and Industrial Applications, Including Furniture," "Methods of Estimating on Plastics Parts," "Design Trends in Plastics," "Applications for Rigid Foams," and "Properties of Various Types of Cellular Plastics."

A special event, the International Forum, will bring together experts on plastics development, production and applications from all over the world. Authorities from more than 51 countries are expected to participate.

For details on registration, technical programs and a complete list of exhibitors, see the November issue of M/DE.

THE HARD SELL



"Now I put my hand on this side and I can't feel a thing."

Soviet Technical Data Now Being Translated

Translations of Soviet technical information will now be available to American science and industry as a result of the establishment by the U. S. Dept. of Commerce of a Foreign Technical Information Center.

According to Commerce Secretary Sinclair Weeks, "The program will add substantially to the wealth of technical information that the Office of Technical Services (OTS) can

METAL SHOW—See pp 19-25 for complete details on registration, technical program and exhibitors at the 40th National Metal Exposition and Congress, Oct 27-31, in Cleveland.

STEEL CASTINGS* help build dependability into the modern cargo carrier . . .

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Transporting America's products by truck-trailer is a gigantic, ever-increasing task—calling for dependable, rugged, long-lasting equipment.
This is the reason many manufacturers of over-the-highway carriers specify *foundry engineered UNITCASTINGS* for many component parts.

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And . . . *foundry engineered UNITCASTINGS*, produced by superior methods, assure steel castings that are internally sound . . . surfaces that are clean and dimensionally accurate . . . and require minimum finishing. Lower *finished* cost is the *real* advantage of specifying UNITCASTINGS. Write for complete information today!

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News of Industry

supply to industry in any field." Services to be provided by the new center include publication of translated abstracts of all articles appearing in 141 Soviet technical journals, translations of important sections (biology, chemistry, physics) of *Referativnvy Zhurnal* (the Russians' own abstract journal), and a semimonthly review of various areas of Soviet science compiled by the Central Intelligence Agency.

Abstracts of each issue of the 141 journals may be purchased from OTS on a subscription basis or single issue basis, as may CIA's *Scientific Information Report*. The various sections of *Referativnvy Zhurnal* will be sold initially as single issues, but subscriptions may be offered later.

Some of the magazines to be abstracted include: *Metallography and Metal Working, Metallurgist, Refractories, Steel and Nonferrous Metals*. Some of the general areas to be covered in the abstracts include: aeronautics, astronomy, chemistry and chemical engineering, civil engineering, electrical engineering, fuel and power, geography and geology, mechanical engineering, medicine, military science, mining and metallurgy, physics, and science and technology.

Complete translations of Russian articles and books are presently being distributed by OTS. Translations are listed in an abstract journal which began publication in September.

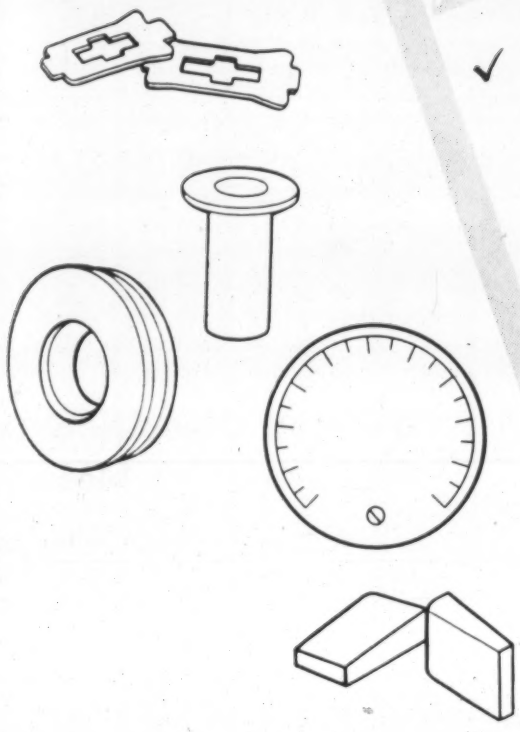
For further information, contact OTS, U.S. Dept. of Commerce, Washington 25, D. C.

Vacuum Symposium Set for Oct 22-24

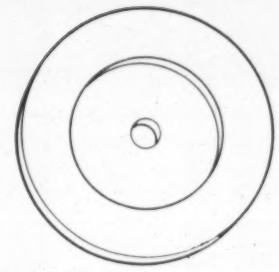
The fifth National Vacuum Symposium, sponsored by the American Vacuum Society (formerly the Committee on Vacuum Techniques), will be held Oct 22-24 at the Sir Francis Drake Hotel, San Francisco.

The program will be divided into five categories: 1) fundamental basis of vacuum techniques, 2) applications of vacuum in pure and applied science, 3) vacuum systems and components thereof, 4) instrumentation and control, and 5) vacuum processes

What do YOU need in a Laminate?



- ✓ Excellent Electrical Properties?
- ✓ High Physical Strength?
- ✓ Complex Machined Parts?
- ✓ Permanent Nameplates, Dials, Charts?
- ✓ Rugged Molded Parts?



There is a MICO LAMICOID® LAMINATE to meet all your requirements

Designing switchgear or a motor? A meter or a transformer? Dial plates or instrument panels? In these and hundreds of other products, MICO LAMICOID components provide outstanding mechanical and electrical characteristics. 27 years of laminates manufacture, continuous research on new and existing grades and complete facilities are your assurance of top quality products, engineered to your requirements.

FORMS AVAILABLE

Lamicoid laminates are available in sheet, rod or tube form in all standard NEMA paper, fabric and glass base grades. In addition, Mica Insulator has one of the most fully eqipped sections for fabricated parts in the country. Two shops — one in Schenectady and one in Monrovia, Cal. — are maintained to provide you with prompt deliveries.

DECORATIVE LAMICOID

Mica Insulator specializes in graphic and engraved decorative laminates too. Opaque or translucent types in a wide variety of color combinations or wood grain materials are available.

2-DAY SERVICE

Ample stocks of standard grades of LAMICOID laminates are maintained in Schenectady, Chicago and Los Angeles. You can be assured of 2-day — frequently overnight — shipment of your orders for standard material.

SEND COUPON FOR MORE DETAILS

Mica Insulator
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..... Send technical data on Lamicoid Laminates.
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SILICONE & TEFLON*COATED CLOTHS & TAPES

* T. M. E. I. DuPont de Nemours & Co.

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DESIGNERS AND ENGINEERS!

Self-Lubricating

Morganite solves today's critical design problems!

Eliminate

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- STICKING
- DISTORTION
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- CONTAMINATION
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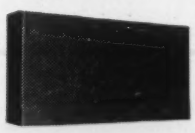
—with MORGANITE

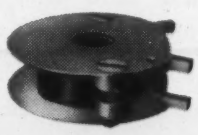
Bearings, Seals, Piston Rings, Valves, Slides, Contacts, etc.

Insure trouble-free operation in continuous service in high temperatures and pressures, oil, corrosive acids, gases, grease and grime. Morganite components "step-up" efficiency, reduce failures and machine down-time. Install application-tested MORGANITE components for better performance on aircraft and industrial fuel pumps, meters, food and processing equipment, jet engine pumps, radar equipment, conveyors, compressors, sealed mechanisms and wherever lubrication is a problem. Engineering bulletins on typical applications available on request.

CALL OR WRITE now, for complete information or recommendations on your specific applications. Morganite engineers will gladly assist in working out your problems.



Jet Engine Pump Vane



Current Collector

Drum Controller Contact

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Morganite ... FOR OVER HALF A CENTURY

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INCORPORATED 3324 48th Avenue Long Island City 1, N.Y.

Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts.
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

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News OF INDUSTRY

and their industrial applications. Some of the papers scheduled for presentation include: "Vacuum Process Evaluation," "Stress Analysis —Glass-to-Metal Seals for Critical Vacuum Systems," "Rates of Evaporation of Various Alloys at Temperatures from 1400 to 2400 F" and "Some Properties of Vacuum Treated Bessemer Steel."

Revised Classifications for Insulating Materials

A little over a year ago, the American Institute of Electrical Engineers published a set of revised standards on electrical insulating materials which included new definitions and designations. The new designations are based on operating performance (temperature) as opposed to composition of materials, the previous method of classifying.

According to AIEE, the revised standards have been receiving slow, but steady acceptance. Listed below are the new classifications; old classifications are in parentheses:

90 C (Class O)—Unimpregnated materials (or combinations of materials) such as cotton, silk and paper, or other materials capable of operating at 90 C (195 F).

105 C (Class A)—Impregnated or coated materials (or combinations of materials) such as cotton, silk and paper, or materials immersed in a liquid dielectric, or other materials capable of operating at 105 C (220 F).

130 C (Class B)—Materials (or combinations of materials) such as mica, glass fiber and asbestos with suitable bonding substances, or other materials capable of operating at 130 C (265 F).

155 C (Class F)—Materials (or combinations of materials) such as mica, glass fiber and asbestos with

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Versatile ACIPCO SPUN TUBES

Stainless steel, carbon steel, alloy iron or special analyses—versatile ACIPCO tubes are "custom-spun" to the exact physical, chemical and metallurgical specifications required by design, manufacturing and end-use conditions.

Because they are centrifugally spun, the metal grain structure of ACIPCO tubes is dense, non-directional and porosity-free. This *superior* grain structure not only makes ACIPCO tubes easier to machine to close tolerances, but also results in greater strength and durability. In addition, the inherent dimensional stability and concentricity of ACIPCO tubes make dynamic balance easier to attain in finished products.

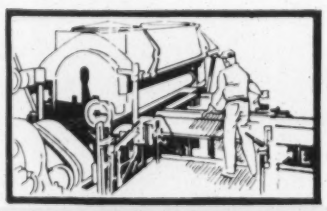
ACIPCO's complete, integrated facilities for casting, heat-treating, machining, fabricating and testing offer the additional advantages of "one source—from start to finish" service.

Call or write today for information about ACIPCO tube applications in your field, or for expert technical assistance on your specific tubular metal problem.

SIZE RANGE: Lengths up to 410″ have been produced to meet modern machinery requirements. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

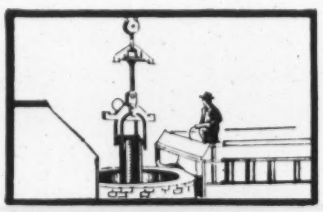
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.



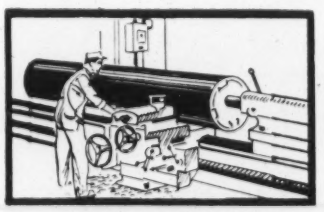
SPINNING

ACIPCO tubes are centrifugally spun to exact physical and metallurgical specifications. Thus, the exact size and metal analysis your process or project requires is assured.



HEAT TREATING

Modern equipment for uniform, controlled heat treating and quenching is an ACIPCO advantage for users of steel tubes where specific physical, mechanical and other metal properties are required.



MACHINING

ACIPCO'S machine shop, one of the South's most completely equipped, performs a full range of machine shop operations including turning, boring, drilling, facing, grinding, metallizing, polishing and honing.

FABRICATION

Complete, integrated facilities for machining, welding, finishing and heat treating of tubular parts save time and expense for ACIPCO customers.

TECHNICAL ASSISTANCE

A staff of highly trained engineers, metallurgists, chemists, and craftsmen is available to designers and manufacturers who specify ACIPCO spun tubes.

Special Products Division

AMERICAN CAST IRON PIPE CO.

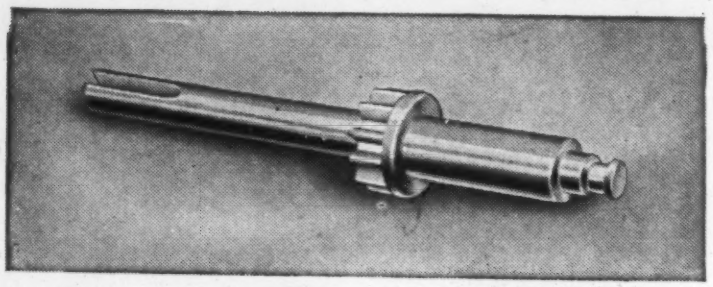
PHONE AL 1-8121, EXT. 285 • BIRMINGHAM, ALA.

For more information, turn to Reader Service card, circle No. 537

here's PROOF of how the GRC method cuts the cost of small parts...

Shown actual size

Take, for example, this part which previously had been produced 3 different ways . . .



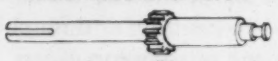
METHOD A

ASSEMBLY OF 2 SCREW MACHINE PARTS

Screw Machine Part

Mill Slot

Machined Extrusion



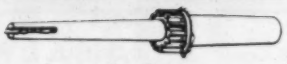
Assembly

4 Production Steps

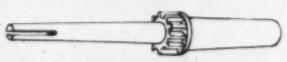
+ 3 inspections

METHOD B

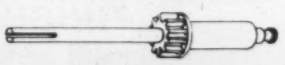
CONVENTIONAL DIE CAST AND MACHINED PART



As Cast



Trimmed



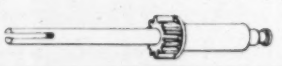
Machining for Undercut and Sizing of Diameters

3 Production Steps

+ 2 inspections

the GRC method

AUTOMATICALLY DIE CAST



1 Production Step

—only **one** inspection

Now take a look at these comparative figures . . .

	Purchased Material	Cost/M	Scrap Generation	Cost in lots of 100 M	500 M
Method A	Brass	$30	30%	$70/M	$69/M
Method B	Zinc Alloy	$3.82	5%	$30/M	$28/M
GRC Method	**Zinc Alloy**	**$3.64**	**None**	**$15/M**	**$11.50/M**

Check the chart; you'll see clear proof of how GRC's DIE CASTING METHOD offers substantial savings on your small parts. The Gries Method delivers parts of high uniformity, with close tolerances . . . ready for use. Assembly and most other secondary operations are eliminated. *Write, wire, phone NOW for GRC's bulletin "Small Die Castings Exclusively"; send prints for quotation.*

MAXIMUM SIZES: 1¾" long, ½ oz. NO MINIMUM

World's Foremost Producer of Small Die Castings

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News OF INDUSTRY

suitable bonding substances, or other materials capable of operating at 155 C (310 F).

180 C (Class H)—Materials (or combinations of materials) such as silicone elastomer, mica, glass fiber and asbestos with suitable bonding substances such as appropriate silicone resins, or other materials capable of operating at 180 C (355 F).

220 C—Materials (or combinations of materials) which by experience or accepted tests can be shown to be capable of operation at 220 C (430 F).

Over 220 C (Class C)—Inorganic materials such as mica, porcelain, glass and quartz, or other materials capable of operating at temperatures over 220 C (430 F).

Copies of the revised standard may be obtained from AIEE, 33 W. 39th St., New York 18, N. Y.

International Meeting on Plastics Standards

An international symposium on Plastics Testing and Standardization has been scheduled immediately following the fall meeting of the American Society for Testing Materials' Committee D-20 on Plastics. The program comprises four sessions scheduled for Thursday and Friday, Oct 30-31 at the Benjamin Franklin Hotel, Philadelphia.

The symposium, sponsored by ASTM on behalf of the American Group of the International Organization for Standardization (ISO), will discuss "How Standards Are Achieved," "Methods of Test for Engineering Properties of Plastics," "Thermal Properties of Plastics," and "Methods for Molecular Characterization."

Beryllium Metal Subject of Symposium

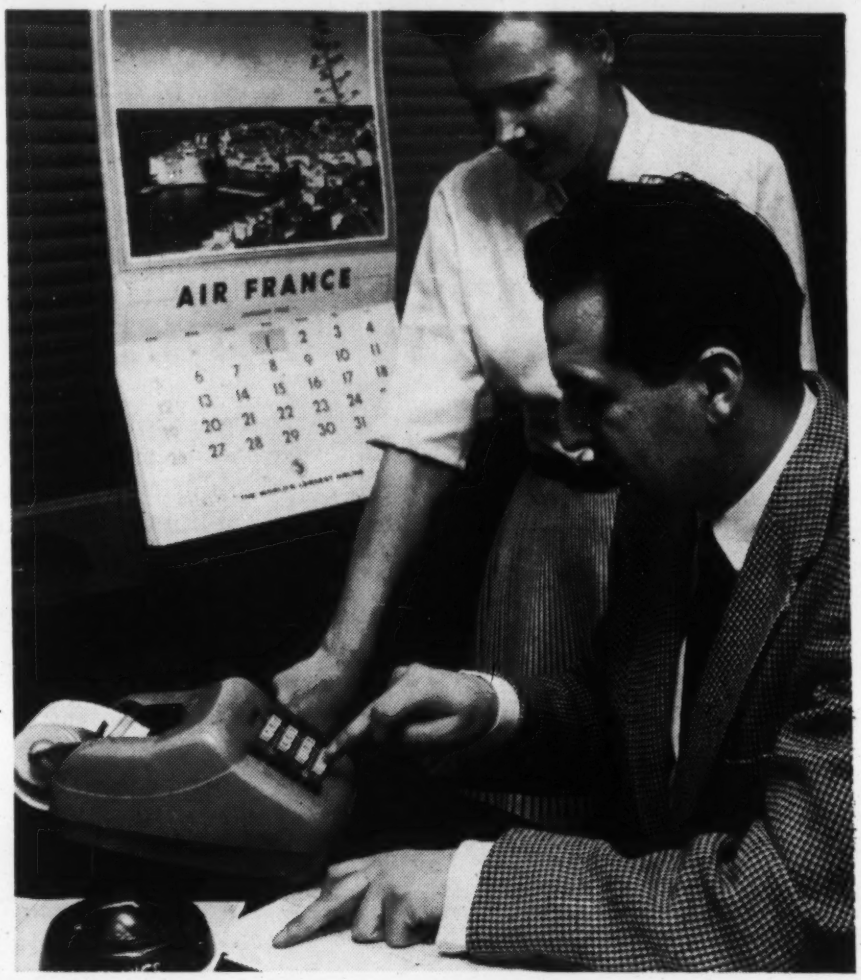
Availability, cost, properties, forming and uses of beryllium were covered in some detail at the first Symposium on Beryllium Metal, recently sponsored by Beryllium Corp.

The symposium, attended by "key men" from the West Coast aircraft

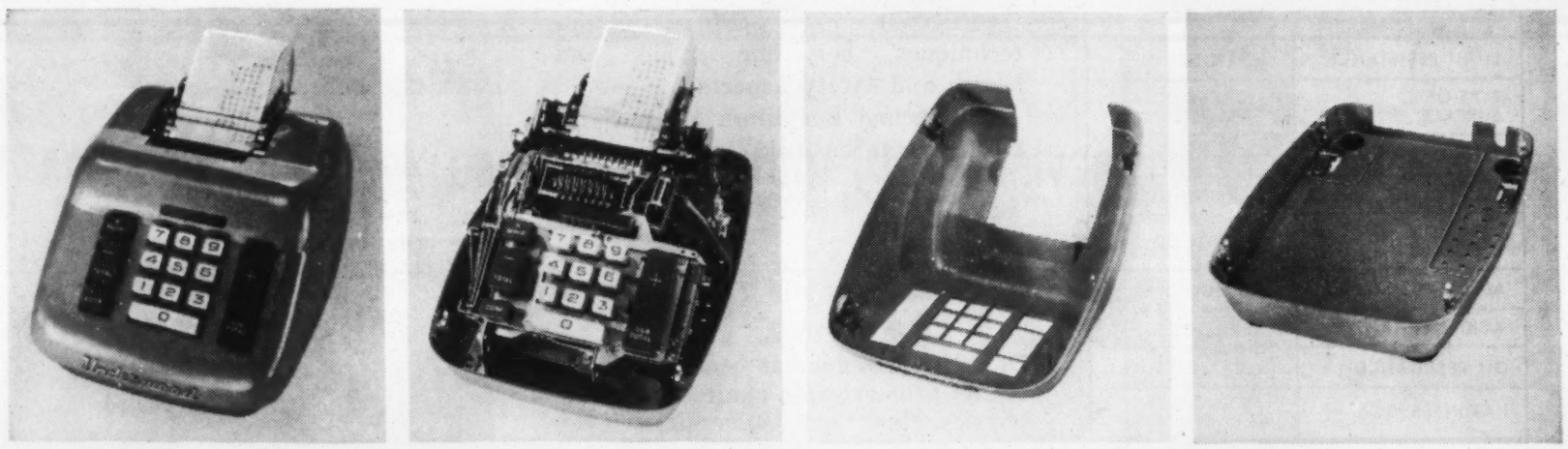
CYANAMID

PLASTICS NEWSFRONT

Midget Adding Machine New Step in Miniaturization



This telephone-size, 7½-pound adding machine, the *Add-Mate*, is Underwood Corporation's newest bid to reduce size and weight of business machines. Easily portable, it can be slipped into a desk drawer or under a counter when not needed. Contributing to its compactness and lightness is the attractive, two-toned housing of CYMAC SUPER* 201 methyl-styrene-acrylonitrile copolymer plastic.



THE COLORFUL TWO-PIECE HOUSING is molded of CYMAC SUPER. Shown above, respectively, are the complete unit, the unit minus the top section, and the inner sides of the top and bottom sections. CYMAC SUPER was selected because of its toughness, surface hardness, and resistance to heat, staining and denting. It is unaffected by the diester permanent lubricant applied to the mechanical assembly prior to encasement in the housing. The transparent, serrated tear-plate, also CYMAC SUPER, and the housing are injection-molded for Underwood by Nopco Plastics, Inc., Erie, Pa.

*Trademark

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
34M Rockefeller Plaza, New York 20, N. Y.

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For more information, turn to Reader Service card, circle No. 483

SLUSH MOLDING

REYNOSOL Slush Molding formulations are being used in an increasingly large variety of operations which include mannequin heads and neck pieces, baby doll head and body parts, electrical parts, and novelties. Typical undercuts found on slush moldings present not the slightest problem to Reynosol, thanks to special releasing agents incorporated into the formulation.

COLOR	UNLIMITED
COST	COMPETITIVE WITH RUBBER OR OTHER FILM-FORMING MATERIALS
AGING PROPERTIES	GOOD
LIGHT RESISTANCE	GOOD
TYPE OF SURFACE	DRY AND GLOSSY
TENSILE STRENGTH	VERY GOOD
SCUFF RESISTANCE	VERY GOOD
ABRAISON RESISTANCE	VERY GOOD
ALKALI RESISTANCE	VERY GOOD
ACID RESISTANCE	VERY GOOD
OIL RESISTANCE	VERY GOOD
HARDNESS	AS HIGH AS 95 (SHORE-A)
% FILM FORMING	100%
VISCOSITY	2,000 TO 4,000 CPS.
TEAR RESISTANCE	GOOD
FIRE HAZARD	NONE

Member Vinyl Dispersion Division, SPI

REYNOLDS CHEMICAL PRODUCTS COMPANY

ANN ARBOR, MICHIGAN

DIVISION OF STUBNITZ GREENE CORP.

For more information, circle No. 509

News of Industry

industry, scientists, engineers, research personnel, and armed forces and Defense Dept. representatives, was created in response to Beryllium Corp.'s offer to share "its basic knowledge of the metal."

The purpose of the symposium was to disseminate knowledge leading to the development of beryllium structural applications. According to Beryllium Corp., substantial interest in the material's possible use in aircraft and missiles has begun to develop during the past year and the need for information on the metal's properties and fabricating possibilities is becoming more and more urgent. As a result, the Air Force and Navy within the past year have begun sponsoring research programs aimed at developing commercial techniques for the production of sheet, rod, extrusions, forgings and fabricated parts.

Some of the subjects covered at the symposium included: availability, cost, toxicity, ductility, other basic property data, applications, research and development, beryllium billets, hot pressing, machining, casting, extruding, forging, rolling, joining techniques, beryllium oxide, and health and safety aspects.

The second Beryllium Metal Symposium will be held in November.

Engineers

Dr. Alfred Seeger has been appointed to a professorial chair in metal physics, New York University.

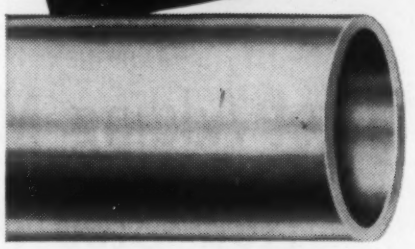
Dr. Schrade F. Radtke has been appointed research director of the industry development committees of the American Zinc Institute and the Lead Industries Assn.

F. Dudley Chittenden has been appointed manager of Marvinol operations, Naugatuck Chemical Div., U. S. Rubber Co.

John R. Hursh has been named chief engineer, and **Paul Buker** supervising product engineer, Armco Drainage & Metal Products, Inc., a subsidiary of Armco Steel Corp.

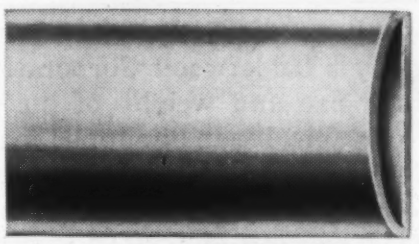
Dr. M. J. Day has been named head of Crucible Steel Co. of America's newly formed Technology Dept. Other appointments in this depart-

EVERYTHING IN *Small Tubing* FOR A PRECISION JOB



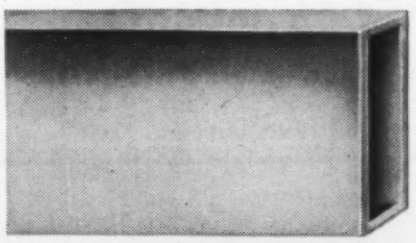
SIZE

.010" to 1.125" O.D. . . . wall thickness down to 0.0015" . . . held to extremely close tolerances.



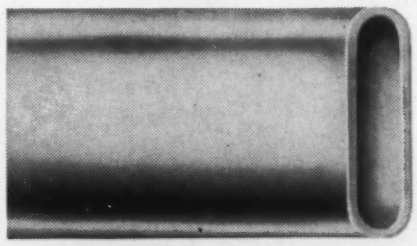
SHAPE

Round, rectangular, oval or square —formed to any specifications.



ALLOY

Copper, brass, aluminum, nickel and nickel-alloys, Ni-Span C, phosphor-bronze and nickel silver.



TECHNICAL DATA

. . . to help your product. Write for Tubing Know-How Booklet to Precision Tube Company, North Wales, Pa.

PRECISION TUBE COMPANY

For more information, circle No. 381

Acres of roof deck panels made from USS Galvanized Steel Sheets

—the zinc stays on

Acres of galvanized steel roof and floor panels are made at Fenestra's West Elizabeth, Pennsylvania, plant. These panels find use in schools, office buildings, stores, plants and many other types of buildings. Fenestra uses USS Galvanized Steel because the continuously hot dip zinc coating remains unbroken through all the fabrication processes; cutting, creasing, cold forming, shearing and welding. The zinc stays on to provide the high degree of protection desired.

You can get the same results using USS Galvanized Steel Sheets. Call our local sales office or write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

Unless otherwise ordered, USS Galvanized Steel Sheets are chemically treated to inhibit the formation of white oxide—sometimes called wet storage stain.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
American Steel & Wire—Cleveland
United States Steel Supply—Steel Service Centers
United States Steel Export Company

USS **United States Steel**

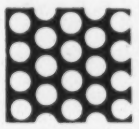
Idea!

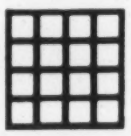
...aesthetic functionalism ...with H & K perforated metals

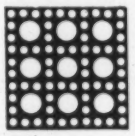
The perception of the Industrial Designer and other men of ideas, in the selection and adaptation of aesthetically interesting and functionally honest mediums, is constantly proving the versatility of H & K Perforated Metals.

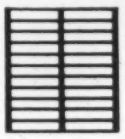
For more than 75 years, Harrington & King has helped to broaden the horizons of industrial design through the creation of unlimited patterns in both metallic and non-metallic materials. If perforated materials can be utilized in your product, our sales engineers will be pleased to work with you.

Write for catalog today! It shows thousands of patterns.









A few of the thousands of H & K patterns are illustrated in reduced size

*Product Development by William M. Schmidt Associates.

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Chicago 44 Illinois

New York Office and Warehouse
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New York, New York

SMALL PRODUCTION RUNS OF PLASTIC PARTS AT LOW COST

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News OF INDUSTRY

ment are: **D. I. Dilworth, Jr.,** director of metallurgy; **W. E. Gregg,** director of technical development; and Dr. **W. L. Finlay,** director of research.

Dr. Mervin J. Kelly, Bell Telephone Laboratories, has received the 1959 John Fritz Medal, sponsored jointly by American Society of Civil Engineers; American Institute of Mining; Metallurgical & Petroleum Engineers; American Society of Mechanical Engineers; and American Institute of Electrical Engineers.

John W. Mayers has been named chief engineer, Pittsburgh Coke & Chemical Co.

Fred E. Hoffmanns is now director of engineering, J. M. Little and Assoc.

H. I. Silversher has been named technical director, International Coatings Co.

A. W. Orlacchio has been appointed chief engineer, Glennite Instrumentation Div., Gulton Industries, Inc.

Marvin F. Hall has been named consulting gas engineer, Ebasco Services Inc.

James L. Wheeler has been named general manager, Die Div., Clearing Machine Corp., a division of U. S. Industries, Inc.

Nicholas Chernik has been named assistant chief metallurgist, Alloy Tube Div., Carpenter Steel Co.

Dr. Paul Schall, Jr., has been appointed chief, Radioisotopes and Radiation Div., and **Dr. James E. Whitney** has been named chief, High-Level Radiation Div., Battelle Memorial Institute.

Donald Z. Erle is now chief engineer, fluid control devices, Hydrodyne Corp.

H. D. Allick has been appointed manager of the Plastics Dept., Chemical Div., Goodyear Tire & Rubber Co.

J. L. Singleton, Allis-Chalmers Mfg. Co., has been elected president of the National Electrical Mfrs. Assn.

Clayton C. Carroll has been named head of the Engineering Dept., U. S. Radium Corp.

John A. Grimes has been appointed general manager, Test Equipment Div., Consolidated Diesel Electric Corp.

Walter E. Gregg has been named director—technical development, and **Dr. Walter L. Finlay** director of

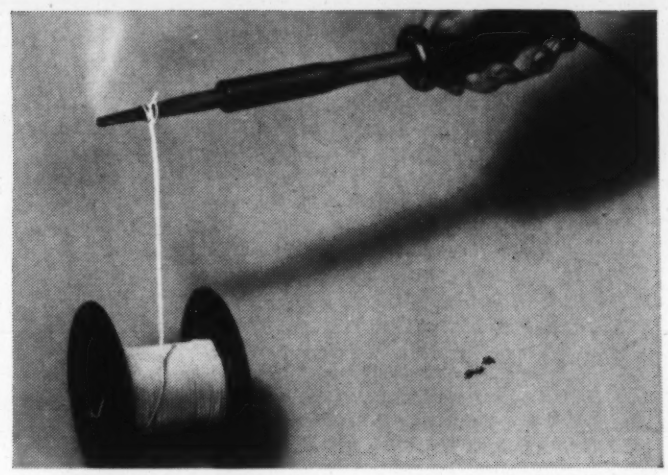
HOW TO SOLVE PRODUCT DESIGN PROBLEMS WITH

GE SILICONE IDEAS

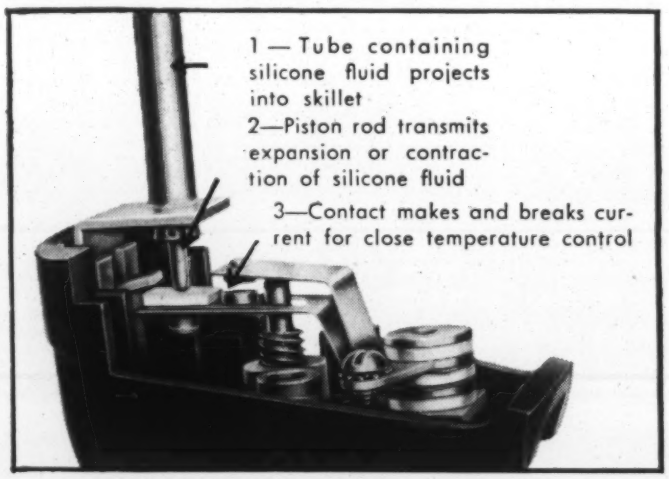
Silicone rubber for wire insulation adds improved physical properties to excellent electrical properties

Always valued for its high performance electrical characteristics at high temperatures, silicone rubber insulation for wire now has improved physical properties. A true elastomer, GE silicone rubber is suitable for thin wall (.012") wire construction, does not tend to cold flow under clamps, can be bent double without cracking, stays flexible down to —150°F.

Even when exposed to a direct flame, G-E silicone rubber still insulates, won't release toxic fumes. Withstands current overloads of 300%-400%, provides a safety margin for intermittent high temperature operation in Class B equipment. Excellent dielectric strength stays high throughout life; service to 500°F—and to 600°F for shorter periods. Features high ozone, moisture and weather resistance, long shelf life.



No damage occurs when you wrap silicone rubber insulated wire around a hot soldering iron, proof of silicone rubber's remarkable heat resistance.


1 — Tube containing silicone fluid projects into skillet
2—Piston rod transmits expansion or contraction of silicone fluid
3—Contact makes and breaks current for close temperature control

New appliance thermostat uses silicone fluids for faster, closer temperature control

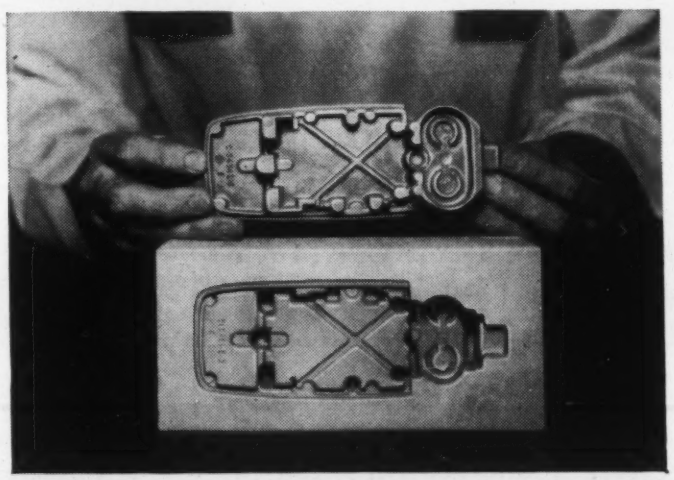
General Electric silicone fluids, because of their high coefficient of expansion and thermal stability, make possible the extremely accurate temperature control provided by the new G-E appliance thermostat. Reaction time is faster than with bimetallic elements; cost fully competitive.

This is only one example of creative engineering with G-E silicone fluids. Their unique properties—small change in viscosity with temperature, chemical inertness, excellent resistance to shear, oxidation and high-temperature breakdown—make them ideal for such applications as dash pots, vibration dampers, heat transfer fluids, fluid transmissions, etc.

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV (room temperature vulcanizing) silicone rubber will do all this and more. Cures without voids at room temperature in any time you select up to 48 hours. Stable up to 600°F. Tough, elastic, bonds well to primed surfaces. Has good resistance to fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.



Sample mold of complex part reproduced exactly, including undercuts. RTV cures without voids, without shrinkage.

OPERATION up turn GENERAL ELECTRIC

Write for more information

GENERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D10B9, Silicone Products Dept.
General Electric Company, Waterford, N. Y.

Please send me further data on:

☐ Silicone Rubber Wire Insulation ☐ Silicone Fluids
☐ Silicone RTV Rubber

Name _____ **Title** _____

Company _____

Address _____

City _____ **Zone** _____ **State** _____

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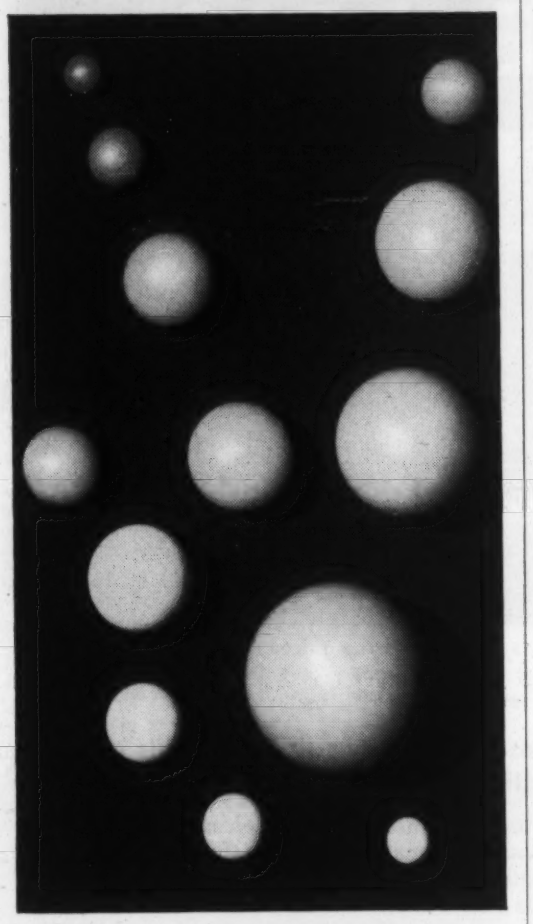
CLEAN AND CLEAR BALLS



OF NYLON AND TEFLON

Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

Write **for prices and specifications.**

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News OF INDUSTRY

research, Crucible Steel Co. of America.

Ray P. Dunn has been named technical director, Lindberg Melting Furnace Div., Lindberg Engineering Co.

John F. Murray has been appointed chief product engineer, Pesco Products Div. and Wooster Div., Borg-Warner Corp.

Walter Clark has been named manager, Air Cruisers Div., Garrett Corp.

Linwood A. Walters has been appointed director of research and development, National Vulcanized Fibre Co.

Richard J. Radcliffe has been named assistant chief engineer—product development and test, Ebco Mfg. Co.

Karl H. Epple has been appointed director of engineering, and **Edward W. McLaren** director of manufacturing, Heli-Coil Corp., Div. of Topp Industries.

Dr. L. H. Sutherland has been named assistant director of research, Escambia Chemical Corp.

Glenn M. Hansen has been appointed process development engineer, Processing Machinery Dept., Allis-Chalmers Mfg. Co.

W. W. Henning has been named manager of engineering, Farm Equipment Group, International Harvester Co.

Companies

Aero-Stat Co. is the new name of Uniseal Co.

CFI (Ceramics for Industry) Corp., Cottage Place, Mineola, N. Y. is a newly organized company which will manufacture precision ceramic parts and composites.

Industrial Development Laboratories Inc. has moved to larger quarters at 982 River Rd., Edgewater, N. J.

Columbia-Southern Chemical Corp. has begun construction of a multi-million dollar cement plant at Barberton, Ohio.

Houdaille Industries, Inc. has acquired **Provincial Engineering Ltd.,** Niagara Falls, Ont.

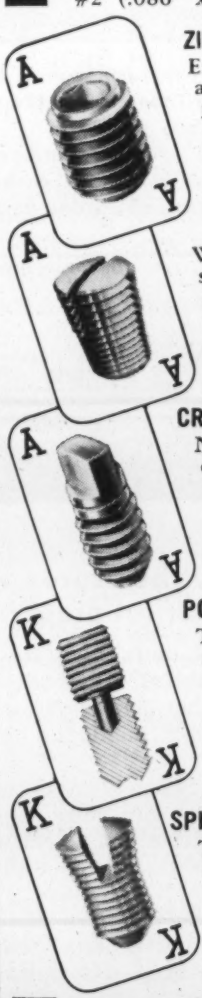
Pyrometer Co. of America, 600 E. Lincoln Hwy., Penndel, Pa., is a newly formed company which will

Full House!

...a setko self-locking set screw for every problem!

... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").



ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.

OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.

POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

FREE, New "SELECTOR CHART" of Self-Locking Set Screws

Illustrates and describes complete range of Setko locking actions, points, metals, combinations, etc. WRITE TODAY... Also ask for our complete catalog No. 23.

Set Screw & Mfg. Co.

149 Main Street, Bartlett, Illinois 1583RR

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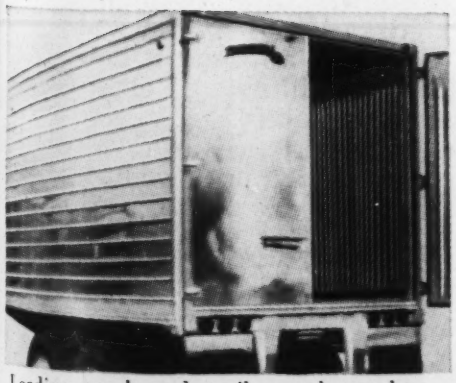
HOW ROYALITE SOLVES 3 BASIC DESIGN PROBLEMS:

TOUGHNESS * BEAUTY * ECONOMY



Leading truck and trailer makers choose damage-free Royalite refrigeration panels that are easy to keep kitchen-clean . . . maintain stable temperature . . . keep weight at a minimum . . . and reduce cooling costs.

Royalite, most versatile of thermoplastic sheet materials, has proven itself time and again to scores of manufacturers . . . in hundreds of varied applications. **Toughness:** Tote boxes of Royalite have built-in resistance to hard knocks. Seamless, easily cleaned, no sharp edges to snag or splinter, quiet, impervious to oils, grease and most chemicals, really lasts. **Beauty:** luggage of Royalite allows modern concepts in molded designs . . . lightweight, pleasing textures, wide range of built-in colors, impact, scuff, and dent resistant, easily cleaned, lasts longer in travel. **Economy:** picnic cooler with pure white Royalite liner provides a non-conductor material with built-in thermal breaker at no extra cost . . . seamless, easily cleaned, odorless, can't rust, deep drawn, modest equipment and labor costs, fabricating techniques permit use on popular priced items. Find out how you can benefit from U.S. Royalite. Let one of our plastics engineers call on you. There is no obligation. Write for information.

Tote boxes by United States Rubber, *Luggage* courtesy of Crown Luggage Co., *Picnic Cooler* courtesy of Coleman Co. Inc., *Refrigeration Panels* courtesy of Trailmobile, Inc.

US RUBBER **Royalite®** A.B.S. THERMOPLASTIC SHEET

US RUBBER **United States Rubber**

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VISIT US AT BOOTH 422—NAT'L. METAL EXPOS.—CLEVELAND, OCT. 27-31.

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News OF INDUSTRY

manufacture instruments, thermocouples and accessories.

Wayne Kerr Corp. is a newly organized subsidiary of Wayne Kerr Co., Ltd., England, and is located at 2920 N. Fourth St., Philadelphia.

Pressure Blast Mfg. Co., Inc., has acquired all assets and manufacturing rights of **Cro-Plate Co.,** Hartford, Conn.

General Electric Co.'s Foundry Dept. has begun operations in its new $750,000 Applied Research and Development Laboratory.

Hofman Laboratories, Inc., has built a new 22,000-sq ft plant in Hillside, N. J.

Sun Chemical Corp. has purchased **Coating Materials Laboratories,** Nutley, N. J., as the beginning of a long-range expansion and modernization program.

Motorola, Inc., and Sibley Co. have been elected to membership in the Institute of Printed Circuits.

Titeflex-Pacific Div. is the name of a new plant opened in Santa Monica, Calif., by Titeflex, Inc.

Comptometer Corp. has acquired **Kord-Mar Co.,** Wilmette, Ill.

Stanley-Humason, Inc., a subsidiary of the Stanley Works of New Britain, Conn., is the new name for Humason Mfg. Co.

Societies

American Society of Tool Engineers announces the following recipients of national honor awards for outstanding contributions to tool and manufacturing engineering: Lester L. Colbert, Chrysler Corp.—ASTE Progress Award; Jesse Daugherty, Giddings & Lewis Machine Tool Co. —ASTE Engineering Citation; J. Everett Hollingsworth, Long Beach City College — ASTE Education Award; Dr. Max Kronenberg, Consulting Engineer — ASTE Research Medal; Andrew E. Rylander, *Western Machinery & Steel World*— Joseph A. Siegel Memorial Award; and Dr. Milton C. Shaw, Massachusetts Institute of Technology—ASTE Gold Medal.

Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers

PUT A-P-C'S
SIXTH SENSE
in Stainless Steel Craftication to Work for You!*

High Versatility!

ONE PIECE OR A MILLION

Many customers have used the term "a SIXTH SENSE" in describing A-P-C's unusual talent in stainless steel . . . And A-P-C has such a wide range of equipment — such great versatility in production *that one piece or a million are welcomed.*

Deep, unbelievably deep and complex draws . . . unusual, A-P-C designed automatic heli-arc welding machines . . . extensive machining facilities . . . and 29 years of experience in a wide range of products and components are ready to go to work for you.

**Craftication is our term for fabrication by A-P-C's skilled craftsmen*

ALLOY PRODUCTS CORP.
1070 Perkins Avenue
Waukesha, Wisconsin

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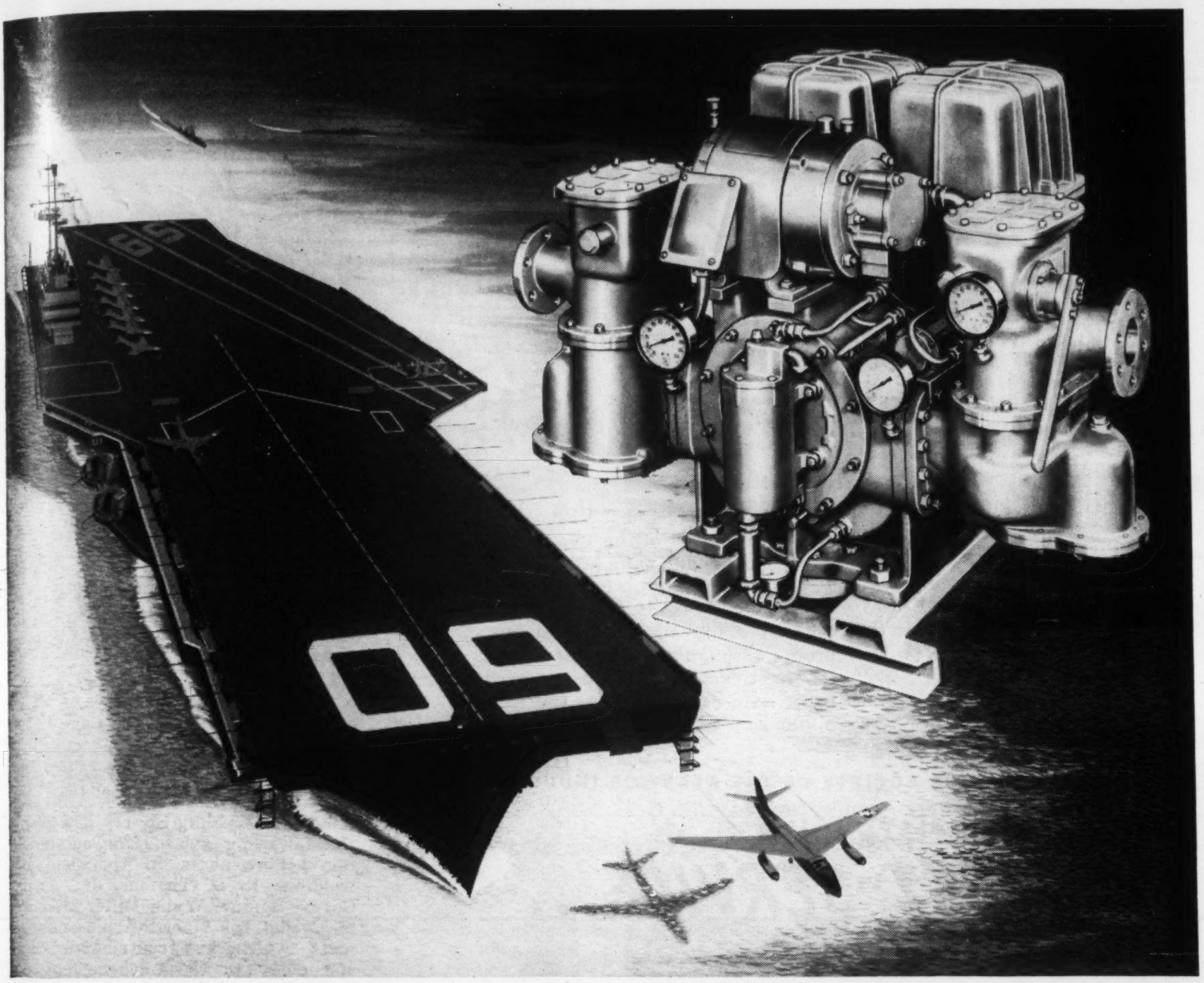

How Kanigen® coating helps eliminate rust from jet fuel systems

Fuel systems engineers faced a major problem in corrosion when jet aircraft went to sea. Aircraft carrier systems for fueling planes are aqua-systems—which means that to prevent accumulation of explosive vapors in half-empty tanks, water replaces fuel as it is pumped out of the carrier storage tanks. Blackmer fueling units, made by Blackmer Pump Company in Grand Rapids, Michigan, frequently are used.

High test aviation gasoline does not absorb moisture. Jet fuel does. This moisture, with high salt content, reaching unprotected steel castings, created rust which contaminated the fuel and caused malfunctioning.

Blackmer pumping units, made from steel castings to meet high shock requirements, were protected with KANIGEN® nickel-alloy coating. They were used and evaluated at sea for two years.

The KANIGEN coating was found superior because (1) it gave better initial overall coverage, and (2) the KANIGEN coating did not chip or break away from machine surfaces as some other coatings do.

If you have a corrosion problem, consult our engineers. You'll find *. . . it pays to plan with General American.*

KANIGEN®

is a trademark which identifies chemical nickel coating by GENERAL AMERICAN TRANSPORTATION CORPORATION and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

KANIGEN DIVISION

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle Street • Chicago 90, Illinois *Offices in Principal Cities*

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NOV. 17-21

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WEARING PARTS

Sound castings of any size, shape or section, rough cast or machined to precisely controlled tolerances. Difficult oil grooving... smooth even around acute bends.

Write for literature and service data sheets, or send prints and condition of operation for recommendations and quotations.

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Saves Time, Tools & Money!

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Lorain, Ohio, U. S. A.

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News of Industry

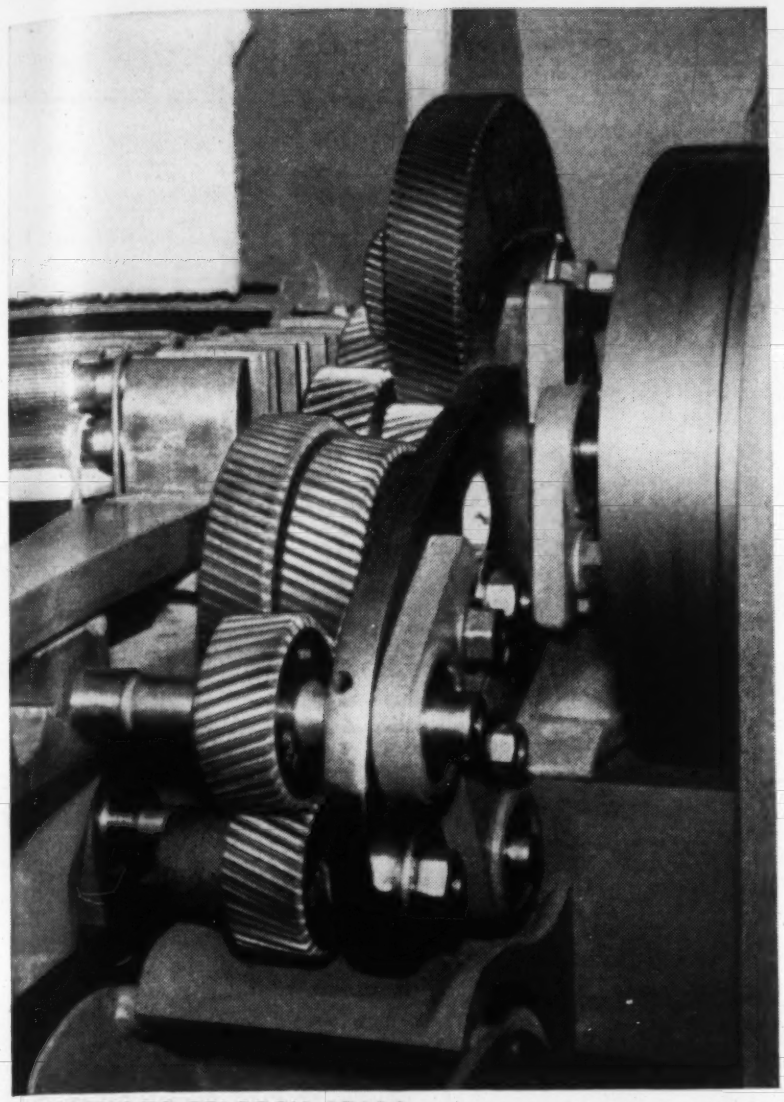
announces the following 1958 officers: president—Stanley D. Michaelson, Kennecott Copper Corp.; president-elect—J. W. Woomer, J. W. Woomer & Associates; past president—Elmer A. Jones, St. Joseph Lead Co.; eastern regional vice president—Dr. Charles E. Lawall, Chesapeake & Ohio Railway; central regional vice president—G. Donald Emigh, Monsanto Chemical Co.; western regional vice president—Dr. James Donald Forrester, University of Arizona; treasurer—Raymond B. Ladoo, consultant; and secretary—John Cameron Fox. New directors are: Raymond B. Ladoo, consultant; Brower Dellinger, National Lead Co.; Carl T. Hayden, Sahara Coal Co.; and Norman L. Weiss, American Smelting and Refining Co.

American Iron and Steel Institute has elected the following three new directors: John L. Neudoerfer, Wheeling Steel Corp.; Walter A. Sterling, Cleveland-Cliffs Iron Co.; and N. P. Veeder, Granite City Steel Co.

American Welding Society has given the following awards for outstanding achievements in the field of welding: R. D. Thomas, Jr., Arcos Corp.—Samuel Wylie Miller Memorial Medal for "meritorious achievement which has contributed conspicuously to the advancement of the art of welding and cutting"; Perry C. Arnold, Chicago Bridge and Iron Co.—J. F. Lincoln Gold Medal for his paper, "Problems Associated with the Welding of T-1 Material"; Clarence E. Jackson, Linde Development Laboratory — National Meritorious Certificate Award in recognition of his "counsel, loyalty and devotion to the affairs of the Society and his outstanding contributions of time and effort in behalf of the Society"; Leon C. Bibber, U. S. Steel Corp.—Honorary Membership in the AWS in recognition of "his exceptional accomplishments in the development of the welding art"; and Lynn S. Beedle and George C. Driscoll, Jr., Lehigh University—A. F. Davis Silver Medal for their paper, "The Plastic Behavior of Structural Members and Frames."

American Society for Engineering Education announces the following 1958 officers: president—William T. Alexander, Northeastern University; vice presidents—Clarence L. Eckel, University of Colorado, and Elmer C. Easton, Rutgers University; and treasurer — John Gammell, Allis-Chalmers Mfg. Co.

(News of Meetings on p 222)



CELORON-TO-CELORON GEARS in drawing rolls made by Ideal Industries, Inc., Bessemer City, N. C. These are helical-cut gears—the toughest to machine, requiring the toughest material. Celoron is it. Other Celoron parts for this application are shown below, top right.

Put strength, long life, silence into gears and couplings with CDF Celoron® molded plastics

WORK MIRACLES IN MACHINERY with this amazing golden phenolic material! Celoron gears help eliminate noise and reduce wear on mating metal gears. Even the roughest-used helicals last . . . and last . . . and last.

HIGH MECHANICAL STRENGTH. Typical Celoron strengths: tensile, 6,500 psi; flexural, 10,000 psi; compressive, 25,000 psi; shear, 8,500 psi. Dimensionally stable and readily machined, Celoron fills the bill where costly metal parts fail.

ELECTRICAL INSULATION VALUE. Celoron is a non-conductor with high electrical insulation value. It makes ideal mechanical-electrical parts. Celoron couplings effectively insulate motors from driven machinery.

CDF FABRICATION SERVICE. Let the plastics-fabrication and molding experience of CDF save you time and money, and assure you delivery of production quantities of CDF plastics and molded parts—on time and as specified. The CDF man can help you from the very beginning. See his phone number in the Product Design File (Sweet's). Or send us your print or your problem, and we'll return samples and technical literature for your evaluation.

CDF **CONTINENTAL-DIAMOND FIBRE**

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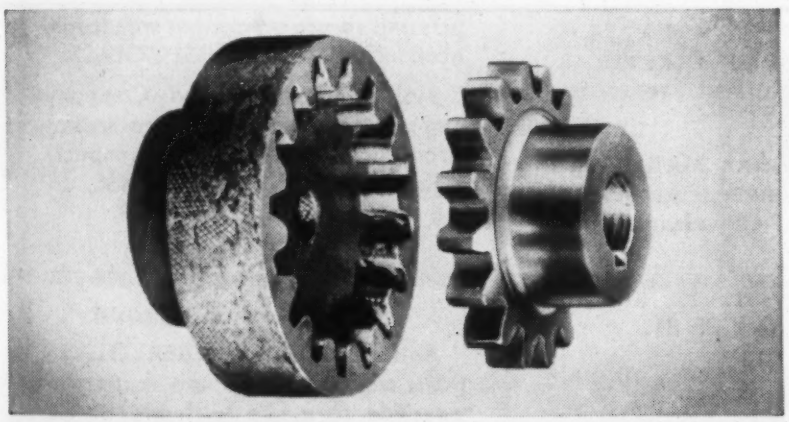
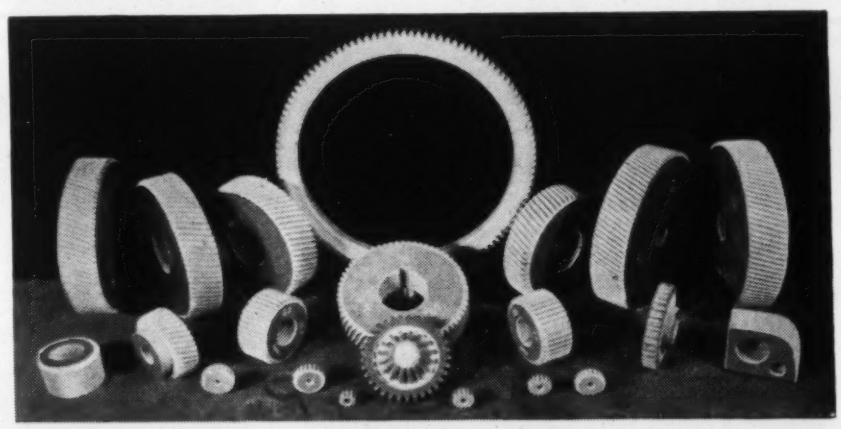
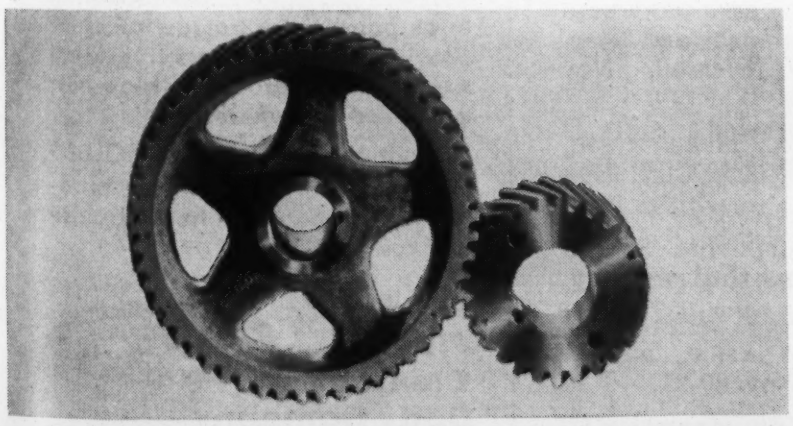


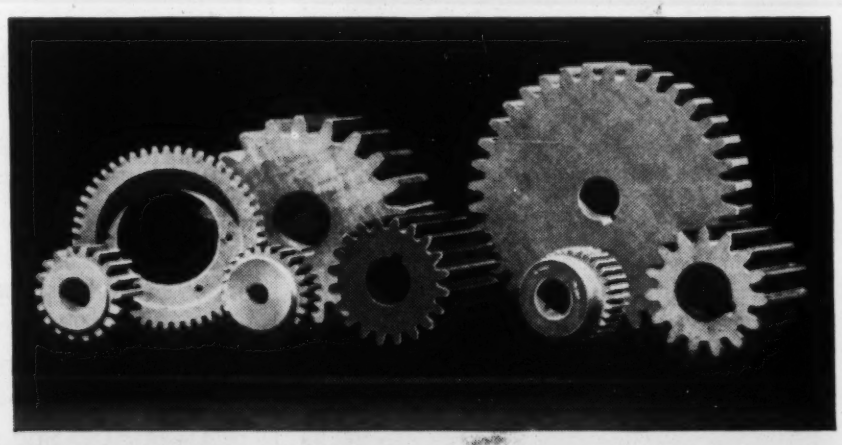
LOW-COST, EASILY-ASSEMBLED CDF Celoron flexible coupling transmits power smoothly, silently . . . insulates motor from machine . . . needs no lubrication . . . works vertically or horizontally.



PRECISELY MACHINED KEYWAYS help keep these Celoron parts silent and strong in the Ideal drawing rolls illustrated in top photograph. Note wide range of sizes and shapes.



CELORON-TO-STEEL combination makes this long-wearing timing mechanism for gasoline engines. Celoron gear absorbs shock, cuts sound to a minimum, holds timing longer.



STRONG, SILENT CELORON makes both drive and driven gears. In fact, many machine applications are 100% Celoron geared for light weight, elimination of excess play, long life.

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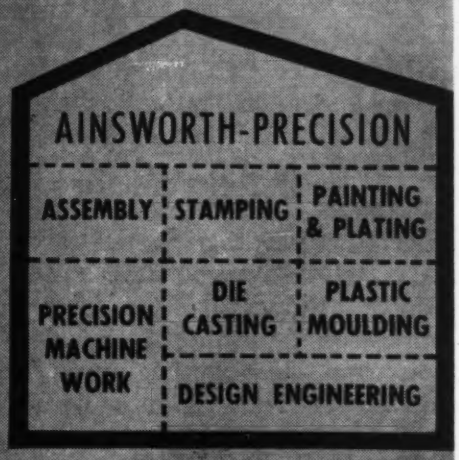

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News OF INDUSTRY

Meetings

GRAY IRON FOUNDERS SOCIETY, INC., annual meeting. Washington, D. C. Oct 8-10.

DESIGN MATERIALS SHOW, Industrial Designers Institute. New York City. Oct 8-10.

METAL POWDER INDUSTRIES FEDERATION, fall meeting. French Lick, Ind. Oct 8-11.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS AND AMERICAN SOCIETY OF LUBRICATION ENGINEERS, joint lubrication conference. Los Angeles. Oct 14-16.

MAGNESIUM ASSN., fall meeting and exhibit. Detroit. Oct 16-17.

FOUNDRY EQUIPMENT MFRS. ASSN., INC., annual meeting. White Sulphur Springs, W. Va. Oct 16-18.

AMERICAN VACUUM SOCIETY INC., 5th national vacuum symposium. San Francisco. Oct 22-24.

AMERICAN GEAR MFRS. ASSN., semi-annual meeting. Chicago. Oct 26-29.

INSTITUTE OF METALS DIV., American Institute of Mining, Metallurgical & Petroleum Engineers, Inc., fall meeting. Oct 27-30.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Pittsburgh. Oct 27-31.

1958 ANNUAL NATIONAL METAL EXPOSITION AND CONGRESS, American Society for Metals. Cleveland. Oct 27-31.

METAL TREATING INSTITUTE, annual meeting. Cleveland. Oct 29-31.

SOCIETY OF VACUUM COATERS, annual fall meeting. Detroit. Nov 5-6.

NATIONAL TOOL & DIE MFRS. ASSN., annual convention. Philadelphia. Nov 5-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, 13th annual technical and operating conference. Cleveland. Nov 10-12.

NATIONAL ELECTRICAL MFRS. ASSN., annual meeting. Atlantic City. Nov 10-13.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. Albany, N. Y. Nov 12-14.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Nov 20-21.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York City. Nov 30-Dec 5.

Large parts, too, can be mass-produced of strong, lightweight
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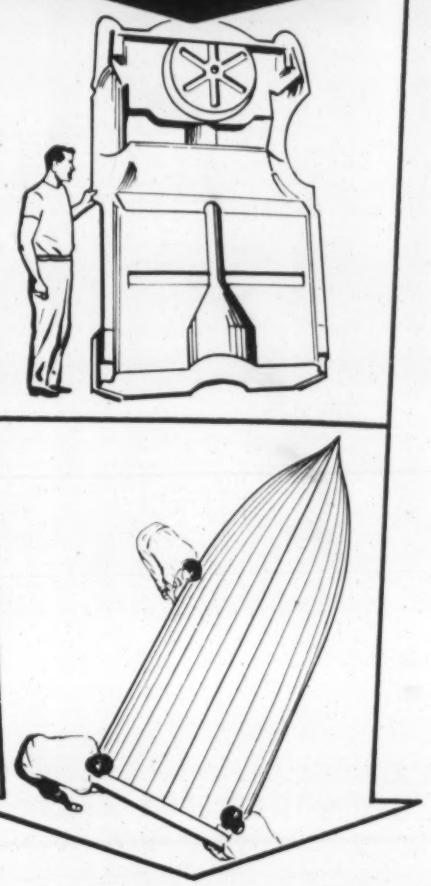

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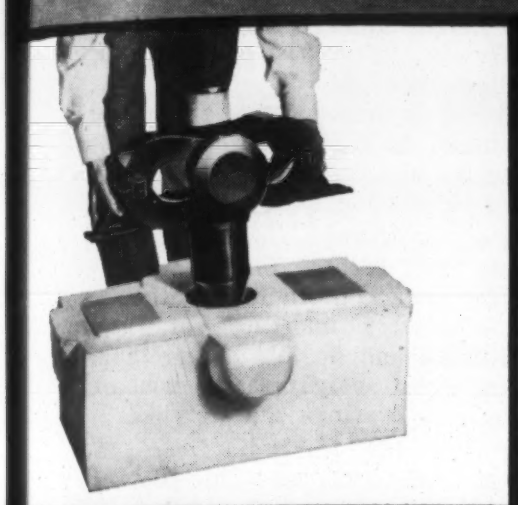
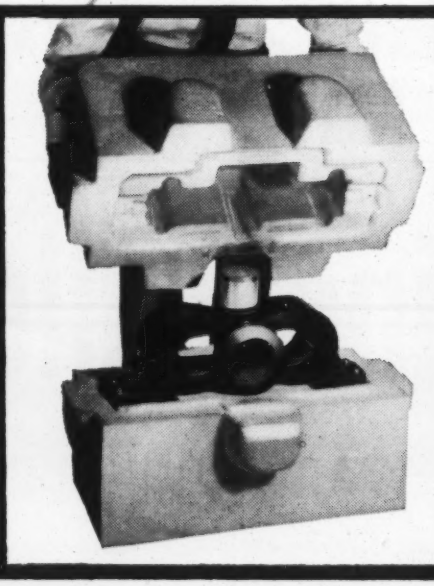
For more information, circle No. 439

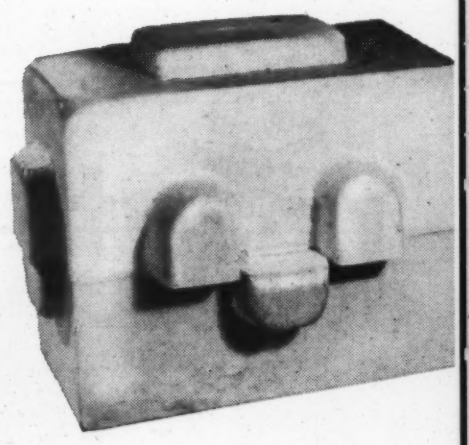


HERE'S HOW G.E. PROTECTS MAGNETRONS SHIPPED TO DEW LINE

Photos show how molded urethane package safeguards General Electric magnetron against shock and vibration in a simple corrugated carton—even at 50° below zero! Magnetron is bolted to aluminum plate bonded into bottom pad during molding. Projections molded at sides of pads provide air-space moisture barrier.

Costly conventional packaging would be 50% bulkier, 300% heavier! New package was developed by Standard Plastics, Inc. of Fogelsville, Pa.





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Urethane foams ranging from flexible to rigid are well worth investigation wherever impact absorption, vibration isolation, comfort cushioning, thermal or acoustical insulation, or added structural rigidity is needed. Their unusual mechanical and dielectric properties are broadly controllable to meet your special requirements.

Being equally versatile in fabrication (molded, sprayed, poured to foam in place, or worked from slab stock) urethane foams frequently permit substantial production economies while they solve your difficult design problems.

If you have a potential use for urethane, perhaps our application laboratory can assist in its development. We produce NACCONATE® Diisocyanates, essential urethane components.

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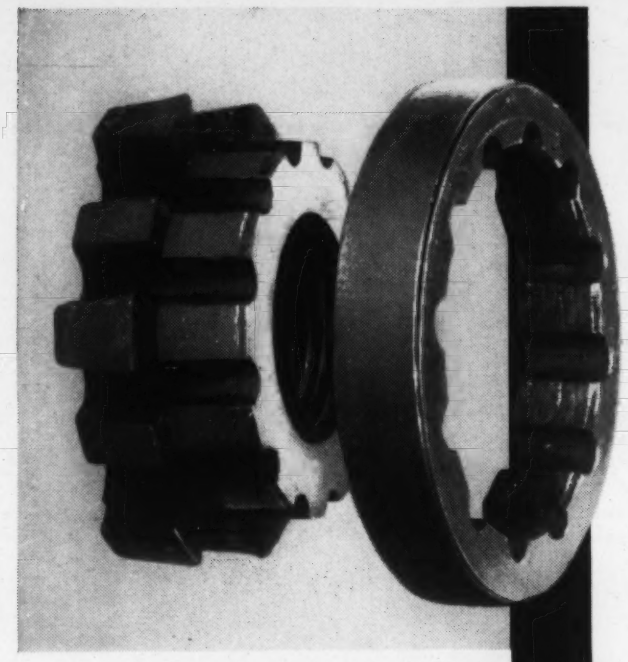

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TECHNICAL LITERATURE

(cont'd from p. 41)

Books

Books on Plastics. *Reinhold Publishing Corp., New York. Plastics Applications Series. Cloth, 5 by 7½ in. Price $4.50 each*

Plastic Sheet Forming. *Robert L. Butzko. 1958. 190 pp.* This book outlines the use of plastics sheet forming in making many different products. It includes information on material selection, equipment, molds, sheet decoration and costs.

Polyurethanes. *Bernard A. Dombrow. 1957. 185 pp.* The 11 chapters in this book contain information on the chemistry and uses of rigid, semi-rigid and flexible polyurethane foams, and polyurethane rubbers, adhesives, coatings and textiles.

Polyamide Resins. *Donald E. Floyd. 1958. 234 pp.* This book establishes a rough relationship between application on the one hand and chemical composition and structure on the other for various types of polyamides. The book discusses polyamide coatings, films, fibers and adhesives.

Effects of Radiation on Materials. *Edited by J. J. Harwood, H. H. Hausner, J. G. Morse and W. G. Rauch. Reinhold Publishing Corp., New York, 1958. Cloth, 6 by 9 in., 360 pp. Price $10.50*

The changes that radiation produces in metals, ceramics, plastics and other engineering materials are thoroughly discussed in this new book. The book contains the papers presented at a colloquium held recently at Johns Hopkins University.

Subjects covered in the book include: effects of radiation on the electronic and optical properties of inorganic dielectric materials; influence of radiation on corrosion behavior of metals and alloys; and effects of radiation on behavior and properties of polymers. An extensive bibliography brings together literature on the subject from every part of the world.

Tooling for Metal Powder Parts. *George H. DeGroat. American Society of Tool Engineers, Detroit, 1958. Cloth, 253 pp. Price $7.50*

H. E. Conrad, Executive Secretary of ASTE, describes this book as a ". . . volume that will prove invaluable to anyone in industry who wants complete information on the potentials and limitations of this rela-

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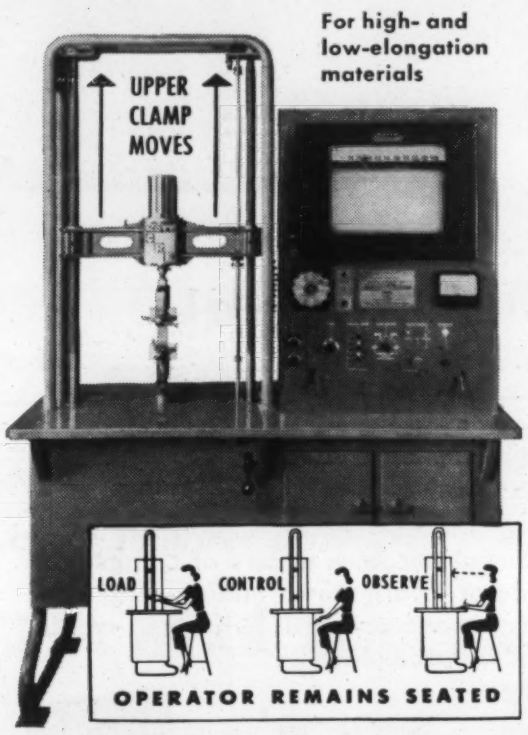

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TECHNICAL LITERATURE

tively new process."

The book gives answers to such questions as: Why are ordinary coolants seldom used on powdered metal machining operations? What is the relative cost of different sintering atmospheres? How does the metal powder process compare with turning or stamping in regard to tool, equipment and materials cost?

The book contains 10 chapters which discuss planning and economics for the metal powder process, design of structural metal powder parts, production and preparation of powders, briquetting presses and tools, sintering structural parts, and finishing operations.

Constitution of Binary Alloys: 2nd Edition. *Max Hansen and Kurt P. Anderko. McGraw-Hill Book Co., New York, 1958. Cloth, 6 by 9 in., 1300 pp. Price $32.50.*

This book, a revision and translation of an original German work titled *Der Aufbau der zweisloffegierungen,* provides a source of reliable data concerning the constitution of binary alloy systems (phase diagrams) and the crystal structure of metallic phases. Included are 1334 binary alloy systems and 717 phase diagrams. The diagrams differ from those contained in the original German edition in that they are presented linearly in atomic per cent rather than in weight per cent. The present volume contains 9800 references to the world's metallurgical physical, chemical and crystallographical literature on binary alloys.

1957 Supplements to Book of ASTM Standards. *1957. American Society for Testing Materials, Philadelphia. Paper, 6 by 9 in. Price $4 per part; $28 per set.*

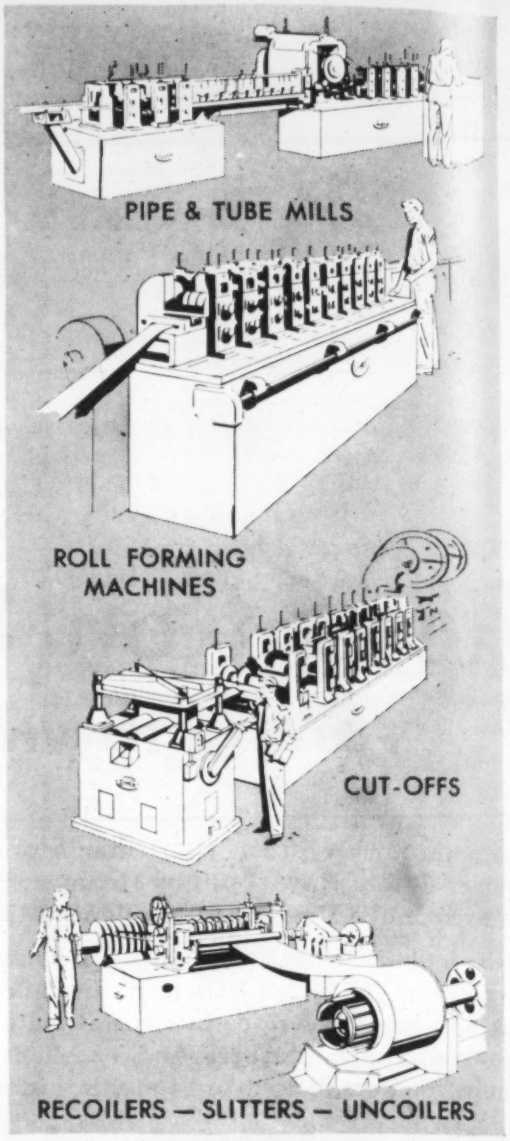
The 1957 Supplements, issued in seven parts, give 415 specifications, tests and definitions which either were issued for the first time in 1957 or revised since their appearance in the 1955 Book or the 1956 Supplements.

Part 1: 520 pp. includes 80 standards covering steel pipe, tubes, castings, sheet and strip; cast iron; spring steel, and metallic coated steel products.

Part 2: 380 pp. Includes 56 standards covering aluminum- and magnesium-base alloys, copper and copper-base alloys, and die cast metals.

Part 3: 360 pp. Includes 60 standards covering refractories, porcelain enamel, glass; thermal insulations and other materials.

(continued on p 228)



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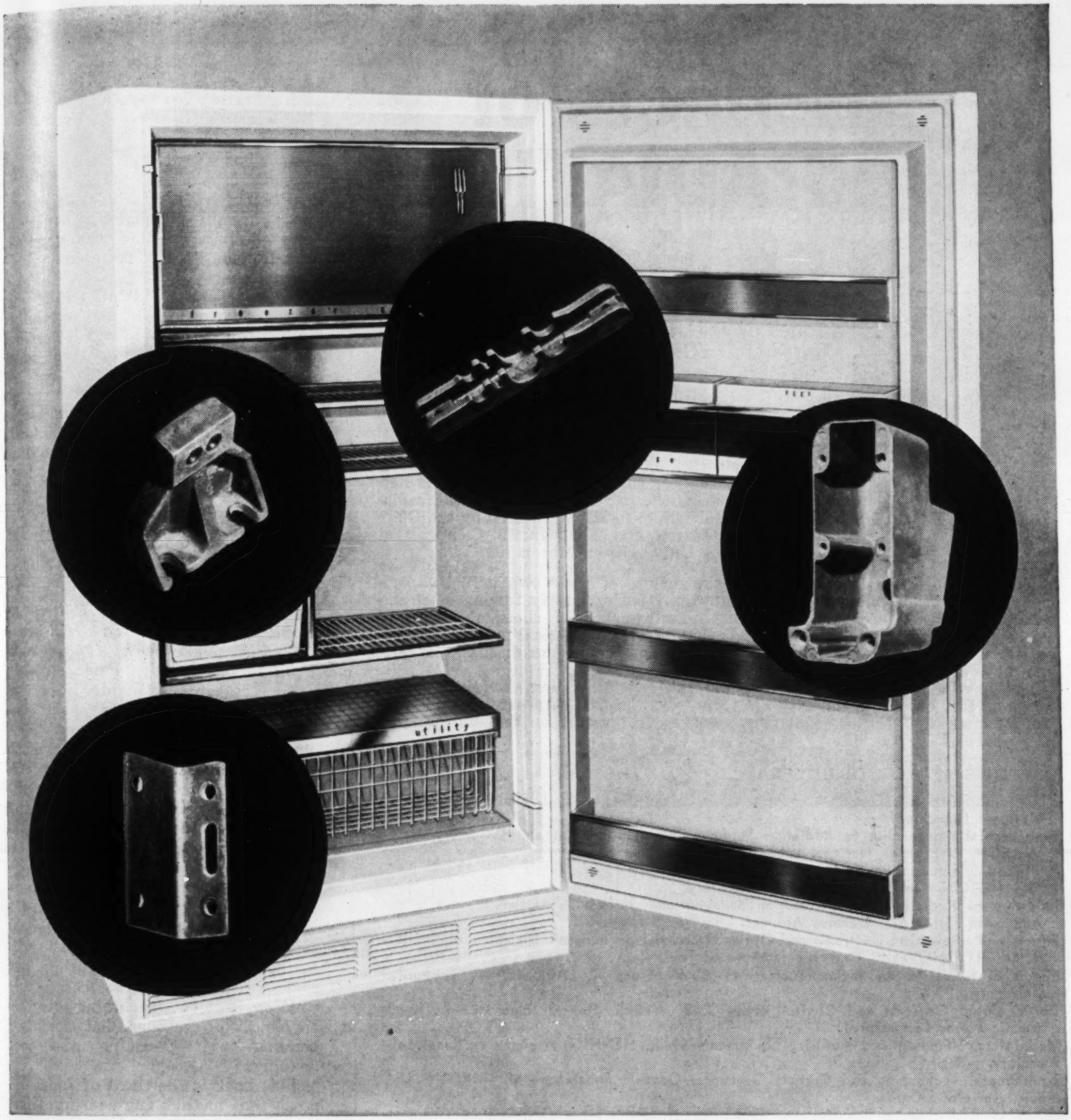

Kelvinator gets big benefits from premix moldings

Premix moldings are making an important contribution to performance of Kelvinator refrigerators.

Strike mounting plates, tie-straps, tubing retainers and lock housings for the Kelvinator are all premix moldings. They've proved tough and resilient . . . excellent shock absorbers. And their thermal insulating properties contribute to the economical operation of the refrigerator.

When resins and reinforcing fibers are blended beforehand, moldings are stronger, wall thicknesses more uniform, weak spots are eliminated. Small and large, simple and complex, premix moldings are not only improving products but cutting costs for hundreds of manufacturers.

If your product calls for strong, rigid, reinforced plastics, look into premix moldings made with Dow vinyltoluene or Dow styrene. Get the names of molders and suppliers from your nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Dept. 2207G-1.

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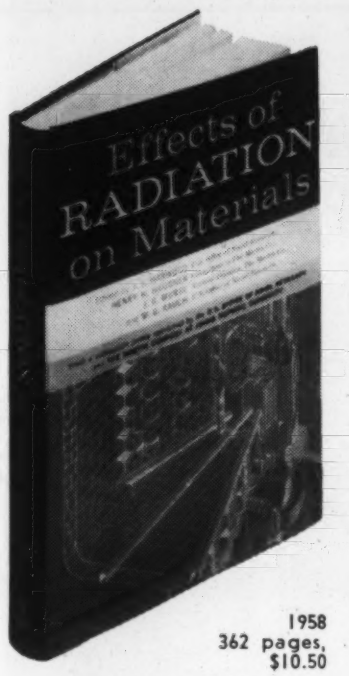

1958
362 pages,
$10.50

Effects of RADIATION on Materials

Edited by **J. J. HARWOOD,** U. S. Office of Naval Research; **HENRY H. HAUSNER,** Consultant to The Martin Co.; **J. G. MORSE,** Nuclear Div., The Martin Co.; and **W. G. RAUCH,** U.S. Office of Naval Research

The changes that radiation produces in metals, ceramics, plastics and a wide variety of other materials are thoroughly covered in this momentous new book. It contains the papers delivered at the radiation effects colloquium jointly sponsored by the Office of Naval Research and The Martin Company at Johns Hopkins University in March 1957.

Twelve leading authorities analyze the results of their own actual experiments with various materials. Solid state physicists classify fundamental and qualitative effects according to type. Metallurgists and chemical engineers make a quantitative evaluation of radiation effects on physical properties. The book also includes current concepts of radiation effects and discusses experimental approaches to radiation studies.

The outstanding authorship, and the subject's timeliness and importance establish this book as a milestone in technical literature. An extensive bibliography brings together the enormous amount of literature on the subject from every part of the world.

CONTENTS AND CONTRIBUTORS:

Defects in Solids and Current Concepts of Radiation Effects—G. J. DIENES, Brookhaven National Laboratory.
Experimental Approaches to Radiation Studies—Radiation Sources and Desimetry—J. C. WILSON, Oak Ridge National Laboratory.
Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys—E. S. BILLINGTON, Oak Ridge National Laboratory.
Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys—M. SIMNAD, General Atomics.
Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials—R. SMOLOCHOWSKI, Carnegie Institute of Technology.
Effects of Radiation on Semiconductors—H. Y. FAN and K. LARK-HOROVITZ, Purdue University.
Cores, Liquid Coolants and Control Rods—C. E. WEBER, General Electric Co. (Knolls Atomic Power Laboratory).
Moderators, Shielding and Auxiliary Equipment—G. R. HENNIG, Argonne National Laboratory.
Experimental Techniques and Current Concepts—Organic Substance—M. BURTON, University of Notre Dame.
Effects of Radiation on Behavior and Properties of Polymers—A. CHARLESBY, Tube Investments Ltd., Cambridge, England.
Kinetics of the Gamma-Induced Graft Copolymerization of Vinyl Acetate to Teflon—A. J. RESTAINO, Nuclear Div., The Martin Co.
Bibliography—H. FRIEDEMANN.

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TECHNICAL LITERATURE

Part 4: 218 pp. Includes 33 standards covering pigments, paint driers and thinners, shellac and varnish, wood, general paint tests, and sandwich constructions.

Part 5: 340 pp. Includes 76 standards covering fuels and solvents; lubricating, turbine and electrical insulating oils; and engine antifreezes.

Part 6: 423 pp. Includes 70 standards covering rubber products, packing and gasket materials, insulated wire, plasitcs, molds and molding processes, and definitions and nomenclature.

Part 7: 280 pp. Includes 40 standards covering textile materials, paper, adhesives and atmospheric tests.

ASME Handbook: Metals Engineering—Processes. *Edited by Roger W. Bolz. McGraw-Hill Book Co., Inc., New York, 1958. Cloth, 7 by 10 in., 430 pp. Price $13.50*

Illustrated with hundreds of line drawings, tables, photos, charts and graphs, this book is a reference manual on various production methods by which metals are converted into finished products. Lewis K. Sillcox, chairman of the ASME Metals Engineering Handbook Board, says the book has been prepared ". . . to fill the urgent need for a reference manual related to the design engineer's point of view."

Composed of 45 sections, the book covers such manufacturing methods as heat treating, casting, hot and cold working, powder metallurgy, welding, cutting, machining, electroforming, die casting, hot forming, bending, press working and cold heading.

This book is the third of four volumes on metals engineering. The first two volumes are concerned with the design and properties of metals; the fourth volume brings together many engineering tables to supplement the designer's knowledge of standards on shapes and dimensions of materials.

Reports

Magnesium alloy DEVELOPMENT OF A CORROSION RESISTENT MAGNESIUM ALLOY. *Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C.*

PART I: DEVELOPMENT OF MAGNESIUM ALLOYS FOR BETTER CORROSION RESISTANCE. *M. Balicki, D.*

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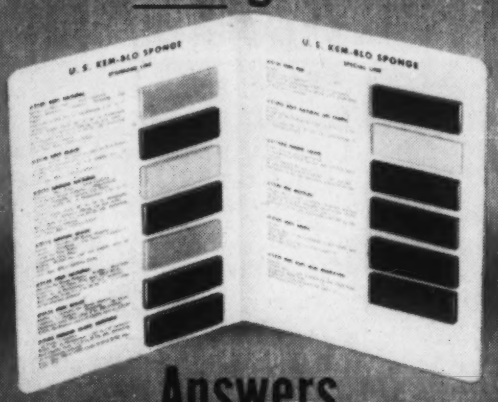

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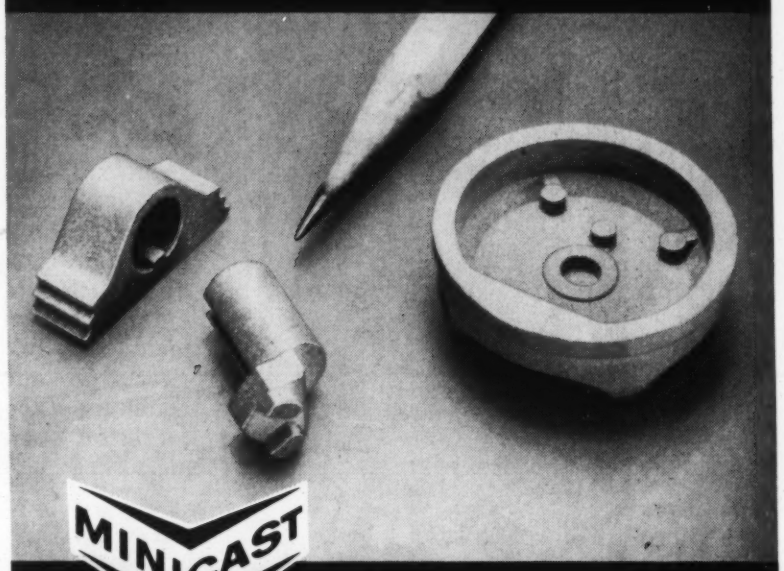

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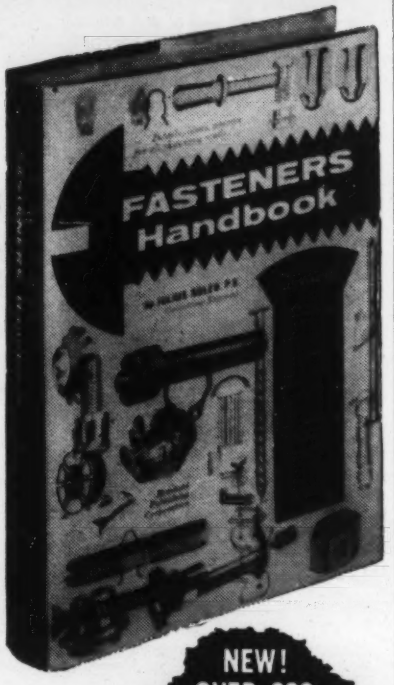

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TECHNICAL LITERATURE

D'Antonia and A. Kravic, Polytechnic Institute of Brooklyn. Aug '57. 38 pp. Price $1 (PB 131443)

Preliminary results indicate that magnesium alloys containing antimony, germanium, indium, tin and cadmium have improved corrosion resistance.

PART II: SURFACE TENSION DATA OF ELEMENTS. *V. P. Siuta and M. Balicki, Polytechnic Institute of Brooklyn. Aug '57. 51 pp. Price $1.50 (PB 131444)*

Data on surface tension of elements can be used to determine the effects of surface tension in such fields as alloying, brazing, casting, corrosion prevention and powder metallurgy.

Strength of metals PROCEEDINGS OF THE 1955 SAGAMORE RESEARCH CONFERENCE: STRENGTH LIMITATIONS OF METALS, *Vol. 1 and 2. Syracuse University Research Institute for Ordnance Corps, U. S. Army. Mar '56. 404 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $10.50 (PB 131280 and PB 131281)*

Cobalt alloys THREE REFERENCE LISTS AND A SPECIAL REPORT ON COBALT-BASE ALLOYS. *1958. Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio*

COBALT IN HIGH TEMPERATURE ALLOYS. *F. R. Morral. 12 pp.* Discusses cobalt production, consumption and availability. Information on some interesting properties of cobalt and cobalt alloys, and comparisons of the properties of various cobalt alloys.

ALUMINUM-COBALT ALLOYS. *4 pp.* Contains references to literature published on cobalt in aluminum alloys from 1908 to mid-1957. Also lists U. S. and foreign patents from 1897 to the present.

COBALT IN CAST IRON. *1 p.* Contains references to literature and patents on cobalt in cast iron from 1930 to 1956.

COBALT IN STAINLESS STEEL. *1 p.* Contains references to literature and patents on cobalt in stainless steel from 1941 to 1957.

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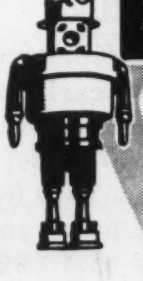

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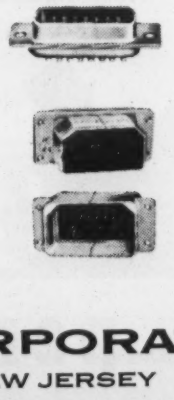

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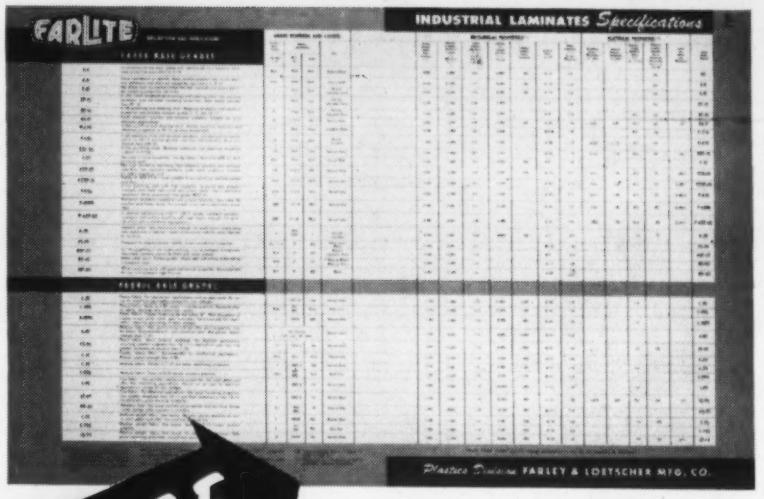

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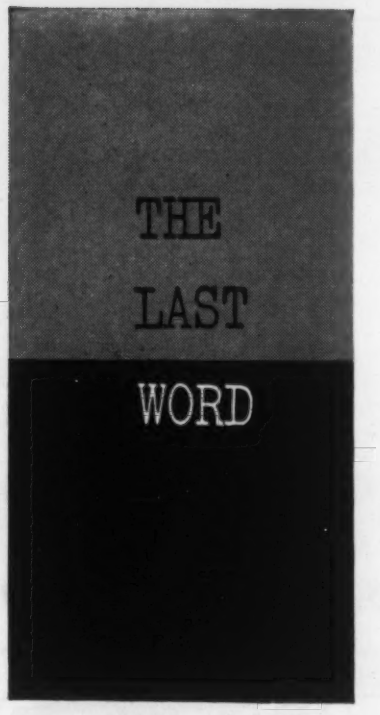

by H. R. Clauser
Editor

West Coast Gossip

I just returned from an extended visit to the West Coast with a briefcase full of notes. Here are just a few excerpts:

▸ Optimism is the single word that best describes the West Coast's predominant mood. "There is nowhere to go but up," is a common expression in California. Many predict and many already assume that in ten or fifteen years the coast from Los Angeles to San Diego will rival the industrial strip from Boston to Washington.

▸ I'm inclined to agree with the Californians. They have good reasons for their optimism. The F108 supersonic fighter and the B70 SAC intercontinental bomber will keep many plants, both large and small, busy for several years to come. Added to this is the massive job of producing jets to replace our obsolete prop-propelled commercial airliners—an undertaking that will probably require at least ten years.

▸ "Honeycomb," the hit tune of a few months back, would be a good theme song these days for the airframe manufacturers. I was told that more stainless steel honeycomb construction will be used in the F108 and the B70 than in any previous plane. Consequently, there are plenty of projects on honeycomb, most of them aimed at bringing the cost down. At present stainless honeycomb can run as high as $100 per sq ft.

▸ A promising competitor to honeycomb is the corrugated stainless steel foil construction that took first prize in our M/DE Awards Competition this year. The fact that designers have little experience with it is a big drawback to its widespread adoption at this time. But according to Bruce Mitchell, of Ryan Aeronautical Co., corrugated foil construction is considerably less costly and is superior to honeycomb in its strength-weight ratio.

▸ The search for lighter weight construction is not confined to the aircraft field. It also has top priority among Ordnance men. The aluminum people on the Coast tell me that the Army has undertaken a long range program to design ordnance equipment and combat vehicles using the lightest possible materials. The Army's aims are to make ordnance equipment light enough to be transported by air and to have maximum speed and maneuverability on the ground. Apparently the day of the massive armored tank is past. The ancient battle between armor plate and the projectile has been won by the projectile. From now on, instead of stopping bullets, the tanks will have to duck them.

Technical Meetings: Dozing on Way Out

Having sat with glazed eyes through many technical meetings, we are glad to see a new trend shaping up. In recent years many societies have been preprinting papers prior to the meeting. However, it is still necessary to sit through the ritual of hearing the paper read in order to hear or participate in the discussion. With commendable solicitude for suffering meeting attendees, the Electronic Industries Association is going to change this. There will be no papers read at their conference on Reliable Electrical Conductors to be held this December in Dallas. General chairman of the meeting R. George Roesch explains:

> "The usual authors of papers will be there, but you will not have to listen to them read their papers. They will be published and offered for sale October 15. You can read the papers before the conference takes place. You can prepare questions which you can ask of the authors. You may also ask questions of other men who are specialists in the field in which you are interested. You will be able to pursue a subject to its bitter end in order to get the facts. You will not be distracted by exhibits. You will not be solicited by men who want to sell you something. You will not be entertained except as you entertain yourself . . ."

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